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Science Students' Problems when Writing a Scientific Paper in English

Case Study: Doctorate Chemistry Students, University of Annaba

Thesis submitted to the Department of English in candidacy for the degree of Doctorate LMD in Linguistics and Applied Language Studies.

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Dedication

May Allah be praised!

My gratitude and warm regard to the beloved parents: Mom ***Zakia*** and Dad ***Kamel*** my loving supporters.

-To my only sister ***Imene*** Biba who kept blaming me for not finishing earlier than now.

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Abstract

English serves as the means of communication in science, technology, business and academic information. In non-English speaking countries, the duties of science students and scientists are doubled because of their need to use English in searching for information in their field of interest and writing scientific articles to communicate their own observations and findings. This need led to the emergence of several problems as the case with Algerian doctorate chemistry students at the University of Annaba who have difficulties writing scientific papers in English. In order to identify those difficulties, scientific articles of 13 PhD chemistry students were analysed through an error analysis method. The detected difficulties were mainly due to their low level in English, the inconvenient way of teaching English in the sciences and basically their lack of experience in writing scientific articles in English. It was hypothesised that if these students received a convenient training in EST, they would overcome these difficulties and enhance their performance in writing scientific articles. A suggested remedy is to design courses about scientific English, mainly how to write scientific articles in English, which is expected to help them achieve the required level in English and communicate their findings correctly and appropriately.

List of Abbreviations

CA	Contrastive Analysis
EA	Error Analysis
EAP	English for Academic Purposes
EBE	English for Business and Economy
EOP	English for Occupational Purposes
ESP	English for Specific Purposes
EST	English for Science and Technology
GE	General English
IMRaD	Introduction, Methodology, Results and Discussion
L2	Second Language
NL	Native Language
NNS	Non-native Speakers
SA	Scientific Article

List of Figures

List of Tables

Table of Contents

Chapter One
English for Science and Technology

Chapter Two
The Scientific Article

Chapter Three
Syntactic and Lexical Features of the Scientific Article

Chapter Four
Research Framework

Chapter Five
Interpretation of the Results

General Introduction

1. Rationale

This dissertation reports an attempt to respond to three major inquiries related to the field of EST (English for Science and Technology). These inquiries are: What do science students and/or scientists need English for? What issues are raised as a result of these needs? And: What should be done to solve these issues and help these students use English appropriately? In order to answer these questions, first, these needs and problems should be identified along with their origins. Second, suggesting a remedy and testing its practicality are required to seek convenient solutions and provide suitable assistance to these students in meeting their needs and solving their problems.

However, science students' tasks and activities, which require the use of English to be fulfilled, are numerous; and the investigation in each one of them demands a separate study. Therefore, the researcher has chosen to look into these students' needs and difficulties with writing scientific articles in English.

A scientific article is an academic published paper that is based on empirical evidence. It presents new pieces of information about recently carried out scientific work such as observations, experiments, findings, solutions, etc. This type of papers has special characteristics and requires not only good and original science to be presented but also a correct language to be communicated. In other words, poor language hinders good science. Language barriers (which are the result of several factors investigated hereafter) can lead scientific articles representing important scientific achievements to be rejected because of the misinterpretation and ambiguity the language can cause to such work.

Thus, the main issue investigated in this study concerns these language barriers, mainly in writing scientific articles in English. The problem primarily emerges due to the nature of the target students who are Algerian doctorate students of chemistry. The problem originates from several factors including: They are non-native speakers (NNS) of English, they have low level in English, they did not gain knowledge in their field of study in English but in other languages, and they were unaware of the importance of learning and using English in their studies. Digging into their difficulties through analysing their writings (particularly scientific articles) is an attempt to define their weaknesses at the level of grammar, lexis and style in addition to the problems related to the scientific article itself such as the format of the article, the specific occurrence of tenses, the use of personal language, etc.

After examining the performance and attitude of these students for quite some time, it can be said that the best solution is to design a curriculum of EST that is based on their needs and provide them with the necessary tools and skills that help them write and communicate their scientific activities correctly and accurately. This training course or curriculum is seen to function better if it is introduced in the beginning of their PhD studies (1^{st} year) when they would be highly interested and motivated to learn and focus. It can also be presented in earlier stages whether at the BA or MA levels in order to gain time and effort especially if the objectives and purposes are previously set and clearly presented.

2. Statement of the Problem

Writing scientific articles in English is an important part of the duties of science students and scientists. It is essential to share the observations and the findings of the scientific work with the scientific community and with the general public as well. The chosen language to share science in the world happens to be English due to many factors including its flexibility and ability to express ideas precisely and accurately. English also allows the accessibility to a great number of resources of information and shared knowledge in the form of articles, books, websites, etc.

However, Algerian chemistry students -as an example of science students- seem not to have been aware of the position of English in their career because they had their studies in Arabic and/or French, and English is a new ingredient for them that appears with such importance only in their doctorate studies. This new acquaintance with English for science led to the emergence of some issues and difficulties that this research is attempting to detect, explain and solve.

3. Aims of the Study

Identification of the difficulties that science students have with English when writing scientific articles is not the only concern in this research. In fact, detecting and examining these difficulties and looking into their sources are a way to understand, summarise ad state these students' needs. The other concern of this study is to propose a convenient remedy to these difficulties and also test its practicality.

The remedy that is seen to overcome these difficulties and write articles more correctly and appropriately is a training in EST in which the features that are most problematic are presented and discussed. This training is a special tutoring where the researcher plays the role of the teacher (of EST) and the sample population are the learners. This tutoring is a course (a group of lessons) designed on the basis of the learners' needs deduced from the previous step (identification of their problems) presenting EST, scientific writing, language features in addition to useful tips and examples.

Moreover, in order to check if the suggested remedy is beneficial and suitable for the target students and can provide the required assistance, more of their writings should be analysed. This analysis can reveal if the tutoring succeeds and what should be modified to make it more reliable for future implications.

4. Research Questions and Hypothesis

The three inquiries mentioned earlier intend to show the observation that led to working on the current investigation, which, as a matter of fact, plans to precisely answer the following questions:

1. What are the difficulties that science students have with English when writing scientific articles?

2. What are the main points that should be clear when writing a scientific paper in English?

3. Which method(s) are used in teaching EST and are they effective?

4. How can such methods be improved to help students fulfil their needs and improve their writing skill?

In the light of these questions, it is hypothesised that:

If science students identified the problems and difficulties that face them when writing scientific articles, they would improve the method of producing this type of papers.

5. Research Methodology

Questionnaires, case study, corpus analysis (*error analysis*) and *tutoring* are the main tools and methods of research applied in this investigation to answer the raised questions and check the set hypothesis. These tools allowed having both a general and a narrowed sight on the students' needs as well as testing the usefulness and practicality of the suggested solution.

The questionnaire administered to the students aims to draw a global image on the students' needs and difficulties concerning their learning and use of English. This broad image helps in clarifying part of the problem and allows deciding the next step, which is corpus analysis.

The selected area of research is writing scientific papers. Therefore, the corpus chosen to be analysed is scientific articles written by the sample students with the condition that these articles are not corrected before (i.e., drafts). This method is applied to get deeper into the students' needs and difficulties. The study of errors (Error Analysis) shows not only the difficulties the students have with English but also possible gaps in their -previous- learning of the language.

The identification of the problem is an important step in designing the solution. Therefore, the next step is a suggested solution (tutoring of a designed course of EST). Time and occupation of the students do not allow for more than the designed course. This course is based on the detected needs and problems, and tries to meet most of them in the time available.

In order to check the practicality and success of this course, another group of articles -written by the same students after conducting the lessons- are analysed. The results reveal whether the course helps in overcoming the problem or not. The second analysis also benefits in enhancing the designed lessons and enables proposing modifications that are seen to improve the suggested course and present it in a better shape in another time.

6. Structure of the Thesis

The dissertation consists of five chapters. Chapters *One*, *Two* and *Three* shape the theoretical part of the study. Theory in this research does not only set the base or frame of the study but also prepares or helps in preparing the tutoring step of the research (the solution to the problem). In order for the researcher to prepare and design the suggested course appropriately and thoroughly, she must sit -to some extent- on solid background knowledge of the material that should be found (in the analysis) and presented (in the lessons). Chapters *Four* and *Five* represent the investigation carried out by the researcher counting the experiment, its steps, the methodology, the results and their interpretation.

Chapter One is about English for Science and Technology (EST) and the scientific English. It presents the characteristics that make scientific English special and unique. It also comprises a brief statement and explanation of the rhetorical devices (provided by Wilkins, 1976 and Trimble, 1987) in order to be used in the lessons for being practical in both writing and reading scientific texts. In addition, it intends to answer an important question asked by the students and similar interested parties, which is: "*Why English?*" This is expected to help students understand the main objectives of learning English (EST). Besides, there is a discussion of the nature, types and significance of audience in scientific writing.

Chapter Two is about the scientific article, which is of interest in this study. It is about the history, format and importance of the scientific papers. It provides the essential details to be considered in each part of the article.

Chapter Three reports the language features in scientific English and its special occurrence in the scientific article including style, lexis and grammar. It covers the areas that are expected to be the most problematic or confusing for science students such as tenses, voice, phrasal verbs, vocabulary, etc.

Chapter Four is a thorough presentation of the investigation starting from the description of the pilot study, which allowed putting this work on the right path. It also presents the description of the main tools and methodology of the research along with the explanation of their choice and application. The main experiment includes, first, a questionnaire administered to chemistry students. Second, it explains the use of an error analysis method to a group of scientific articles written by the same students. The third step is an explanation of the course designed with the intention to solve these problems and fulfil those needs. The explanation contains the presented information and details, the objectives of each lesson in the course and the reaction and feedback of the students. The last step is the second analysis, which aims at checking the practicality and the degree of success of the suggested lessons in the fulfilment of the needs and solving of the problems.

Chapter Five provides the summary, analysis, discussion, and interpretation of the results obtained by the experiment. It presents the students' needs that the first tools of the research seek to find. The questionnaire administered to the students and the analysis of their papers are seen to complete each other in detecting their problems and understanding their needs. The analysis alone could find their difficulties with the language only. That is to say, it could show, for instance, their lack of understanding of grammar rules or vocabulary use. However, the questionnaire provides a wider view on their needs and put their problems on a scheme that enables to reveal their sources. For example, it could unclose to what extent the English lessons they had at university or in previous stages were useful in meeting their current needs. In chapter *Five*, examples of the detected errors are also presented to show the main areas of difficulty in language use. Those examples are classified according to their types and their origins as well. It finally presents the results of the second analysis as the means by which the success of the designed course in solving the investigated problem is checked and evaluated. This analysis reveals more errors related to areas that were not included in the lessons. Thus, the appearance of such errors after the conducted course is explained in order to confirm the set hypothesis.

Chapter One

English for Science and Technology

Chapter One

English for Science and Technology

Introduction

English has become the dominant language of the world in many areas especially in science, technology, telecommunication, business and media. This dominance has been achieved due to several factors; some of them are historical and political, and some others go back to the nature and characteristics of the English language itself.

This chapter attempts to define both English of the scientific discourse in science and technology and the characteristics of scientific writing as compared to General English and literary style. The chapter evenly underlines the specificity of the scientific discourse and the reading-comprehension devices used to deal with this discourse. This is followed by an explanation of the reasons that make English a dominant language in the field of science and technology in particular.

Some definitions of English for Science and Technology (henceforth EST) are highlighted in relation to learners' needs, and its position in the greater field: English for Specific Purposes. Finally, the chapter is terminated by an emphasis on the nature, role and importance of audience when writing in general and when writing scientific papers in particular.

1.1. English for Science and Technology: An Overview

1.1.1. ESP and EST

English for Specific Purposes (ESP) refers to the use of the English language in a particular field of study or work. It is also concerned with teaching this particular use of the language for a specific type of learners. Science and Technology are one instance of these specific purposes, and thus English for Science and Technology (EST) is concerned with teaching English to scientists and/or to students of sciences.

Most importantly, ESP is an approach to language learning based on learners' needs. That is to say, learners' needs determine which language aspects students should focus on. Hutchinson and Waters (1987) state that ESP is distinguished from General English (GE), not because of the 'existence' of needs but because of the 'awareness' of these needs. In other words, identifying the exact needs from an English course makes its content more appropriate, reliable and useful. It, thus, facilitates the learning process for teachers and learners as well as course designers. In the same vein, Seedhouse (1995) states that the major difference between ESP and English as a foreign language (EFL) lies in the learners and their purposes for learning English. ESP students are adults who already have some familiarity with English and are learning the language in order to communicate a set of professional skills and to perform particular job-related functions.

Earlier on, Strevens (1977) categorises the definition of ESP into four brief characteristics. ESP is the English language teaching that is:

> (1) designed to meet the specified demands of a learner, (2) related in content to particular disciplines, occupations and activities, (3) centred on the language appropriate to those activities in syntax, lexis, discourse, semantics, etc., and analysis of the discourse, (4) in contrast with general English. (p. 2)

These features reveal the nature of ESP that it is a specific use of the English language with distinct grammar and vocabulary which make it different from the general use of English. Therefore, teaching ESP and teaching GE are two different areas and that is what should be taken into consideration by ESP teachers and course designers.

ESP, though, is a large field that can be categorised into several subfields. Strevens (1977) divides ESP into two major branches: English for Science and Technology and English for Other Purposes. The former is the major and most popular branch in ESP while the latter includes English for Occupational Purposes (EOP) and English for Educational Purposes (EEP). This division is different from other classifications of what ESP is about. It considers EST as a separate part because of its large audience compared to other uses which are put under the heading “Other Purposes”.

Another interesting subdivision of ESP is that made by Trimble (1985) when he explains that ESP is categorised into EAP (English for Academic Purposes) and EOP (English for Occupational Purposes). This subdivision shows that English is taught for and used by learners as well as workers. Therefore, EST, EBE (English for Business and Economy) or any other parts can belong to both subdivisions in the same time with difference in context and orientations. To give an example, EST can belong to EAP as “EST fields” including engineering, electronics, etc., as it can be part of EOP as “EST occupations” including engineering technicians, electricians, etc. (p. 6). In other words, a worker and a student in a particular technical field require different trainings in language usage.

Similarly, Orr (2005) considers ESP as “the branch of English language education which focuses on training in specific domains of English to accomplish specific academic or workplace tasks” (p. 9). This definition includes divisions as English for Academic Purposes (EAP) and English for Occupational Purposes (EOP), as well as subdivisions such as EST and EBE.

From a different perspective, EST is seen to be one category of EAP, i.e., it is concerned only with the teaching and learning of English for science and technology. EOP, on the other side, is concerned with using English (GE) in work and professions as shown in Figure 1 below:

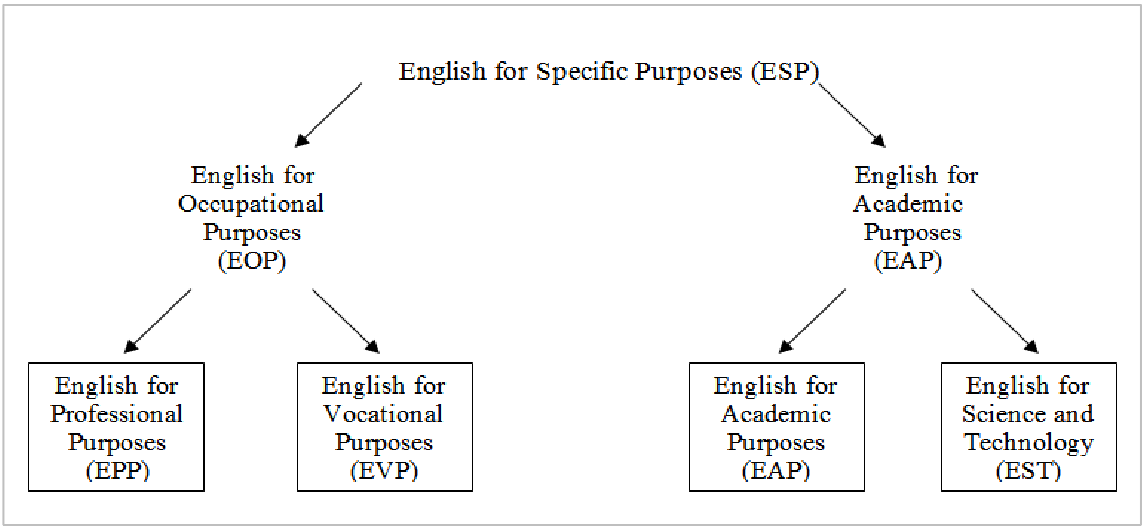

Figure 1. Subcategories of ESP (Johns & Dudley-Evans, 1991, p. 299)

Although EST is considered one major subdivision of ESP, its courses are clearly 'distinct' because of the nature of the fields -science and technology- it is concerned with. These courses "put great emphasis on scientific English and the selection of the appropriate communicative situations that are specifically related to science and technology". (Dorrity, 1983, p. 145)

According to Dudley-Evans (1998), EST is one large branch of ESP in which "it shares some basic characteristics with ESP"; i.e., it stresses particular "purposeful and utilitarian learning of English". In brief, EST is concerned with: Why and how the language is used (p. 8).

Previously, Swales (1985) states that EST is the 'senior' branch of ESP. It is a new and recently emerged field; however, it has more participants and contributions than ESP. As he puts it, EST is "senior in age, larger in volume of publications and greater in number of practitioners employed" (p. 9).

As a practical definition of EST, Munteanu (2011) states that it "is the language used in the professional contexts of natural sciences and technology". Science books, technical manuals, scientific articles, and science and technology textbooks are examples of professional contexts (p. 7).

1.1.2. Learners' Needs

EST is a field that is designed to help international undergraduate and graduate students as well as professionals to use English as a common language in the field of science and technology. Therefore, EST is concerned with what these learners need from the English language. These needs, according to Trimble (1985), are the instructions that EST learners and teachers require to know and learn. Those instructions are the core of EST courses.

Trimble (1985) indicates that EST "covers that area of written English that extends from the 'peer' writing of scientists and technically oriented professionals to the writing aimed at skilled technicians" (p. 5). In this area, there are several types of "instructional discourse that can be thought of as intermediate between the two extremes" (p. 5). That is to say, EST is the use of English in certain ways and with specific means in order to fulfil the needs of learners and professionals of technical subjects. These needs differ from one particular type of learners and/or users of English to another.

The following chart explains the 'types of instructional discourse' that Trimble (1985) mentions in his definition of EST:

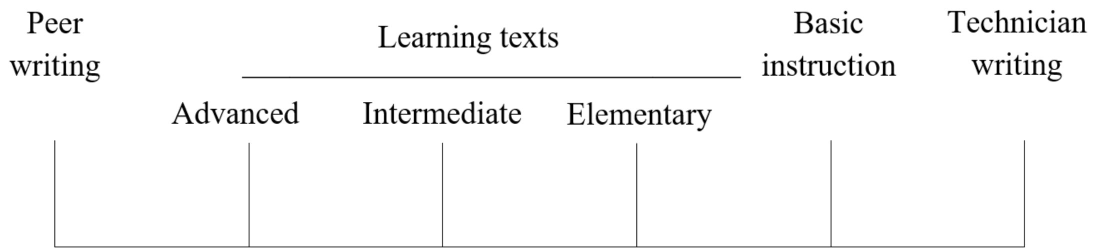

Figure 2. Spectrum of Types of Discourse (Trimble, 1985, p. 6)

Peer writing can be exemplified by books and articles written by experts to other experts in similar field. However, it should be taken into considerations that skilled technicians do not have similar training in theory. Not far from that, scholars as Nunan

(2004a) and Yu et al. (2006) agree that EST is mainly concerned with learners' needs in how it should be considered, planned and taught. It starts from the main objective and the curriculum to course design and then to the usage and application of the language in the particular field of science and technology.

Hans and Hans (2015) describe who these learners can be. ESP -and so EST- students are usually 'adults' who have some previous familiarity with the English language and are learning it in order to "communicate a set of professional skills and to perform particular job-related functions". This means that students and/or workers of different sciences or technological professions, who need English in their studies or professions, should be concerned with EST (not GE).

As an extension to this, Yu et al. (2006) defines EST as "one of the major educational aims of technological and vocational education". EST is crucial for science and technical graduate students which leads to the fact that these learners do not need to learn English in general but 'learner-centred materials' that fit their needs (p. 3). In other words, these learners do not have to learn the general use of English (grammar, syntax, reading and writing) but they need to learn only what they would use in their studies or work.

According to Rao (2017), EST is "very important for the institutions of engineering and technology". In such specific establishments, teaching and learning the language can only be effectively 'achieved' when teachers become aware of their "learners' needs, capabilities, potentials, and preferences in meeting these needs" (p. 46).

Correspondingly, Rao (2017) accentuates the role of teachers of English in achieving the real aim of EST, which is identifying, recognising and reaching learners' needs, and the problems created by ignoring this aim in earlier learning stages (such as in middle and secondary schools). He declares that "it has become a great concern of English teachers [higher education teachers] that most students in technical institutions do not enter college with a satisfactory level of English competence” (p. 49). In other words, there is not sufficient awareness and realisation of these needs and specific purposes of learning English in previous English classrooms. This lack of awareness leads to the problems that face graduate and undergraduate students of English as a foreign language, especially in technical and science institutions.

Similarly, Mansouri (2010) writes that EST is concerned with “meeting the specific language needs of learners” in several scientific and technological domains. He suggests that teachers of English to students of science and technology should take into serious consideration the specific needs and requirements in ‘designing’ their courses. It cannot be an arbitrary process based on general perspectives or necessities. (p. 17)

Teachers of English, in earlier stages as well as in higher education are expected to play a crucial role in EST courses in which they have to be aware and make learners also aware that they are and will be concerned with ESP and EST rather than GE. Thus, EFL course designers should take into consideration this fact and include all the participants in the course design process: teachers, learners and their needs.

Ghafournia and Sabet (2014) go further stating that “the presence of adult learners, who are primary workers and secondary learners” is the outstanding factor and the fundamental component of ESP and EST courses which make them different from GE courses. Therefore, EST is considered a “highly learner-centred approach” in which it is very important to integrate the learners and their needs (p. 1).

It is important to note that in criticising and suggesting teaching methods, syllabuses and courses, Wilkins (1976) emphasises the importance of learners’ needs. His view has changed the vision to the methods and approaches of teaching in general and of ESP in particular. He says that “rather than orientate learning to the subject and its content, we should take account of the learner and his needs" (p. 6). What the learners need from the language determines the content and how it ought to be treated and presented. In other words, the content of English courses addressed to science students as well as other fields is to be selected regarding those students' needs in addition to "the social contexts which learners wish to access" (Feez, 2002, p. 3). That is why teaching EST students should be considered as a "more balanced approach where students' learning needs, i.e., 'the how' are given equal weighting to their language needs, i.e., 'the what'" (Watson, 2003, p. 154).

DeMarco (2011), as well, emphasises the necessity to design EST courses for post-graduate students and workers specifically "to work-related needs or academic objectives". Course designers should bear in mind that these learners are "adults who have studied general English in school but who need to demonstrate on the job proficiency in either a specific skill area such as reading or in a specialised content area such as technical English". Therefore, learners' needs do not only determine how English should be taught but also what should be focused on exactly in matter of suitable content, required skills and specific language points in relation to the particular field it is concerned with.

1.2. The Scientific Discourse

1.2.1. Defining the Scientific Discourse

Before the scientific discourse is defined, the definition of the word 'discourse' must be presented first. The Oxford English Dictionary (2011) defines 'discourse' as "written or spoken communication or debate" (p. 500).

According to Graesser, Gernsbacher, and Goldman (2003), the term discourse "has gone through complex definitional vicissitudes in its evolution over the past seven centuries" (p. 30). In the beginning of its use, the term improved several 'semantic' uses. Throughout history, some of these uses disappeared or changed and by the 19^{th} century, the dominant use or sense had become "a long and serious treatment or discussion of a subject in speech or writing"; a dissertation, treatise, homily, sermon, or the like (OED, 2011, p. 357).

Another operational definition of discourse is that presented by Longacre (1990). Discourse is "an instance of language use"; distinguishing its type depends on grammatical and lexical factors and their choices in "main versus supportive materials, theme, style, and the framework of knowledge and expectations within which the addressee interprets the discourse" (pp. 1-2).

In other words, discourse is a unit of language larger than other units such as the sentence. This unit discusses a specific area of meaning in a particular subject or field (Forgacs, 2000; Fairclough, 2001). There are several types of discourse under this explanation including "academic discourse, legal discourse, media discourse, etc.". However, each of these types "possesses its own characteristic linguistic features" (Bronwen & Ringham, 2000, p. 51).

In Linguistics, Kinneavy (1971) classifies discourse into four major types: 'expressive', 'persuasive', 'literary' and 'referential'. Categorising a discourse into one of these types depends on the element which receives the primary emphasis. If the emphasis is on the sender –the writer or speaker, the discourse then is *expressive*. If it is on the receiver –audience (reader or listener), the discourse is *persuasive*. If on the linguistic form or code –the text (written or spoken), it is *literary*. If the objective is to signify some realities about the world –the content, it is *referential*. The scientific papers and articles in particular are considered an example of referential discourse. (Cited in Swales, 1990, p. 42. [emphasis added]). In effect, Livnat (2010) sees that the scientific discourse is persuasive. The scientific discourse is "an argumentative discourse" because the purpose of which is mainly "to persuade the scientific community to accept the new knowledge and arguments presented" by means of scientific articles. They also aim at making part of the "scientific knowledge or facts upon which there is a consensus within the relevant discipline" (p. 104).

Widdowson (1978) defines the scientific discourse as "a universal mode of communicating, or universal rhetoric which is realised by scientific texts in different languages by the process of textualization". Textualization means all the notions, concepts and procedures that characterise the scientific discourse. Widdowson (1978) indicates that the scientific discourse is independent from any language, stating the fact that most of the scientific text is "non-verbal modes", such as numbers, charts and diagrams, especially in mathematics, physics and economy. This type of modes reflects the feature of 'universality' of science and thus of scientific discourse (p. 52).

Widdowson (1979) also sees that the scientific discourse as "the verbal and non-verbal realization of the communicative system of science" (p. 45). Verbal is the written text and nonverbal can be exemplified with numbers and figures, which the scientific writing makes use of them enormously.

It can be said that the scientific discourse is different from other types of discourse in not only their nature but in some other features including grammar and lexis. However, these are not the only differences. Kennedy and Bolitho (1990) explain that the features of scientific discourse are more than grammar points or lexical items to consider when writing or reading. They are rather considered as "a set of functions" (p. 3). As an instance, an academic discourse is different from a scientific discourse in the purpose of each one of them in addition to the most frequent grammatical factors in each type.

From a different perspective, the main purpose of the scientific discourse as put by Sionis (1997) is "to assert a personal 'new' truth". Thus, it can be seen to be composed of two basic strands. The first strand is "personal and *intratextual* (self-referring)". It is the part represented by the scientists' own "line of reasoning". The second strand is "*intertextual*". It is the part that includes "all exterior reference" which are used by the scientist to support his own stand such as "quotations, mathematical theorems and formulae, previous well-established approaches, etc.". The first stand here relies on the second in order to gain "legitimacy and acceptability" because these external references are considered "solid-truth" (pp. 4-5).

Personal in this context does not mean indications of the writer herself/himself (the scientist) but her/his own contribution to the work s/he presents. In other words, any research paper (including scientific articles, dissertations, etc.) includes, in addition to previous knowledge and discoveries, what the researcher does and finds and how s/he explains it.

As what the scientific discourse is or where it is to be found, Roth (2004) considers that it is by tradition, "the term scientific discourse has been used to refer to special purpose language employed by scientists". It can be employed in the form of the discussions they share in their laboratories or, more precisely, in the form of formal papers and dissertations, journal articles and textbooks as well (p. 50). In other words, the scientific discourse is mainly the communicative expressions used by scientists during and after their discussions and findings, statements, starting from their thoughts and debates during observations and experiments to publishing those thoughts and results in journals.

Similarly, Orellana (2012) explains that the scientific discourse is how a scientist describes his thoughts and work as experiments or results. The scientific discourse is the product of the scientists' own version of using and adapting the necessary supplies and their methods of "structuring the professional scientific activities" (p. 91).

As a general definition of the scientific discourse that sums up all the previous thoughts, Brown (2015) provides that the scientific discourse is simply "the process and methods used to communicate and debate scientific information". That is why it focuses on "how to arrive at and how to present scientific ideas and thoughts". Another feature that may have a great share in defining the scientific discourse is the existence of audience which can be, according to Brown (2015), of several types including "peers, students, teachers, the general public, business and government organizations" as they may exceed to "any other potential audience that may benefit from or contribute to scientific theory and consensus" (p. 304).

1.2.2. The Nature of the Scientific Discourse

The nature of the scientific discourse is similar to that of the science itself which is being persuasive. Since the scientific discourse reveals scientific facts that are based on the scientists' observations and experiments, its aim then is to convince the audience through reasoning and arguing.

Latour and Woolgar (1986) state that scientists are basically "writers and readers in the business of being convinced and convincing others" that their statements should be accepted as facts. Thus, in their different productions, they are expected to present truths and only truths. In view of this factor, a researcher in science must declare what happened exactly even if the experiment meets with failure or the activity does not go well; even failure is a result in science (p. 88).

Therefore, the scientific discourse cannot rely on non-logical evidences such as luck or feelings. They state that "scientific discourse has no privileged status but relies instead on rhetorical and persuasive devices". That is to say, both the text and the content are important in the persuasion process which is a point that should be taken into consideration by all scientists. (Latour & Woolgar, 1986, p. 184)

Bazerman (1988), similarly, claims that persuasion is "at the heart of science". He emphasises this special relationship between persuasion and scientific discourse saying that "the most serious scientific communication is not that which disowns persuasion, but which persuades in the deepest, most compelling manner". It can be achieved through avoiding any "superficial" arguments and obvious or axiomatic evidences and facts (p. 321).

In the same vein, Charney (1993) explains the goal of the scientific discourse and why it should be persuasive. The nature of the scientific discourse is not to tell what happened or what is happening in a particular domain of science, but to convince the readers that what is happening is a fact. That is to say, the aim of scientific discourse is "profoundly argumentative and not merely expository" (p. 204). The main purpose is to persuade the potential readers and to have them convinced that the presented work is valid and important. It also aims at motivating them to accept, recognise and acknowledge the strength and significance of the work by using it as a source of knowledge in further works. It is then to convince and not only to tell.

Another crucial feature of the scientific discourse is being *objective*. Objectivity here means that there is no sign of the writer in her/his writing except the fact that s/he has done the research. In other words, the writing is dependent on the content -science- and independent from the author -the scientist (with rarely occurring exceptions). Kinneavy (1971) denies any interference or contribution of the researcher in the branches of science and technology to her/his research which can be explained in that the writer of a scientific discourse should not use any expression that reveals who s/he is, including personal pronouns (I, we, my, etc.) (Cited in Swales, 1990, p. 44).

Along the same line, Livnat (2010) confirms that research (especially in science) must "be completely independent of the identity, personality or specific circumstances of the researcher carrying it out". In order to achieve this criterion, a considered effort is done in scientific discourse to reduce the researcher's presence in the text which results in an objective style of writing that “ostensibly enables the facts to ‘speak for themselves’” (p. 105).

(This criterion -objectivity- is in the nature of the scientific writing as it is shown in further sections)

Stating the features of scientific discourse leads to speak about an important factor in its development which is audience. Since audience of scientific knowledge is expanding, Brown (2015) explains that the scientific discourse develops to make scientific achievements clear and reach the audience. She states that the ‘specialised’ nature of scientific information led the discourse in science to evolve continually in order to “account for the variation of potential understanding as well as the objectives intended among various audiences” (p. 304). The audience of science is not only scientists.

1.3. Rhetorical Devices in the Scientific Discourse

In view of EST and its characteristics, the scientific discourse and its special features, and learners’ needs and their importance, in addition to the fact that science students -the subject of this research- are non-native speakers of English (NNS), all that lead to take into consideration reading and understanding. These students are expected, not only to write, but also to read, understand and analyse scientific texts during their studies and research; some parts of their articles are taken from previously written works which are mostly published in English. Therefore, in this research and in order to fulfil this requirement, it is worthwhile to provide some comprehension devices related to science communication that are seen beneficial in reading and interpreting as well as writing and constructing scientific texts. These devices are: (1) the “notional categories” deliberated by Wilkins (1976) and (2) the “rhetorical functions and techniques” developed by Trimble (1985).

1.3.1. Wilkins' Devices

Wilkins (1976) discusses the comprehension devices in general; it can be found in any genre of text whether it is academic discourse or simple conversation. Therefore, they can be applied to the scientific discourse. According to him, the use of a word, expression and/or a sentence differs from one context to another. The devices in question are used to spot and understand this difference in the use of words, function of words as well as the relation between words in a larger unit. Two of these comprehension devices, which are useful and important -yet simple- are 'semantico-grammatical categories' and 'categories of communicative function'.

1.3.1.1. Semantico-grammatical Categories

These categories are concerned with the relation between words in a sentence or sentences in a paragraph or even between paragraphs in a text. They are also concerned with the function and use of words in a sentence.

Time is the first category. In almost all languages, "it is scarcely possible to produce a sentence without being involved in expressing time concepts". In this case, the tense system of the language "tends to require choices based on time". Beside tense, time is also expressed in the following aspects: "point of time" (e.g., now, etc.), "duration" (e.g., for five years, etc.), "time relations" (tenses), "frequency" (e.g., always, on Mondays, etc.) and "sequence" (e.g., first, next etc.) (p. 25).

The second category is *quantity*. It is commonly used in scientific texts. It is expressed through 'countable and uncountable', 'numerals' and 'mathematical operations' (p. 31). Chemistry, for instance, involves the use of this category.

The third category is *Space*, which is even more commonly found in scientific texts. It is expressed in 'dimensions', 'location' and 'motion' (p. 32). The chemical context, for instance, makes use of not only formulas and chemical equations, but of description of objects and tools as well.

The fourth is *relational meaning* which is about the choice of words and the relation between these words in a sentence. In other words, “we see certain things in much the same way however differently we may report them in the various languages we speak”. There are ‘sentential relations’ which are the relations between nouns or nouns and verbs that constitute one sentence, such as ‘agent’, ‘object’ and ‘instrument’. These aspects can be similar in many languages, though the aspect of predication and attribution -the position of adjectives in a sentence- differs from one language to another like the case of English and French (p. 34). (This difference between English and French causes difficulties to NNS students as to be shown in further chapters.)

The fifth category is *Deixis* or “the capacity to refer an utterance to the context in which it occurs”. The deictic meaning is conveyed by expressions of *time, place* (of the utterance shown by use of demonstratives ‘this/that’, adverbial expressions ‘here/there’ and others ‘above, below, the former, the latter’) and *person* (pronouns).

1.3.1.2. Categories of Communicative Function

The above-mentioned categories are concerned with the relation between words that constitute a sentence. However, categories of communicative function are concerned with the relation between the sentence and the context where it is used. In Wilkins’ (1976) words, the categories of communicative function are about “the function of the sentence (utterance) as a whole in the larger context in which it occurs” (p. 22).

The function of an utterance in this context does not mean and is not concerned with what is done by the language (to do by the language here can be exemplified by the expression: “*I hire you*” -the speaker has done an action with this utterance). It is rather about the utility and purpose of the utterance. Wilkins (1976) explains that there is a "fundamental distinction between what we do through language and what we report by means of language". In case of NNS students -such as the subject of this study- "the fact that we know how to report does not mean that we know how to do". For that reason, language learning has focused more on the use of language to report and describe than on doing things via language. Here comes the importance of recognising the function of the utterances; "what people want to do through language is more important than mastery of the language as an unapplied system" (p. 41), that is to say ESP.

According to Wilkins (1976), there are "six kinds of thing that we do with the language" which are the most frequent communicative functions. Yet, one expression may have more than one function; "any actual utterance inevitably contains many different kinds of grammatical meaning and may simultaneously perform more than one function" (p. 24). This can be justified that one utterance might be interpreted in more than one way in the same context in which it is used, as it might have another function if used in a different context or situation.

Coming is the list of the most frequent communicative functions with their meaning, use and a context or discourse example:

- The first communicative function is *judgement and evaluation*, which is mainly about assessments. This category can be found in legal and educational discourses.
- The second one is *suasion*, which intends to "affect the behaviour of others". This type is commonly found in scientific and political discourses.
- The third is *argument*, that "the presentation of information can obviously be part of a larger suasive and expository use of language". This category occurs in several types of discourse including the scientific one.
- The fourth type is *rational enquiry and exposition*, which is "the rational organization of thought and speech". It is widespread in different genres of texts since it

is presented in “drawing conclusions, making conditions, comparing and contrasting, defining, explaining reasons and purposes, conjecturing and verifying, inferring and implying” (p. 52).

- The last two categories are *personal emotions* and *emotional relations*, like in greeting and sympathy. However, both categories can never be found in scientific and technical contexts. For instance, a chemist cannot write as an observation: “The poor fish dies because of fertilisers and pesticides split in the river”. (*Poor* here indicates sympathy).

1.3.2. Trimble’s Devices

Trimble (1985) explains that the comprehension devices -rhetorical functions and techniques- provide the readers with “both a framework and a set of relationships” (p. 12). Rhetoric means to speak or to write persuasively. Rhetorical functions are “the foundation of the rhetorical approach to the analysis of written EST discourse” (p. 19). The rhetorical techniques or as Close (1975) calls them “the cohesive ties” are “the semantic elements that show the relationship between the sub-ideas and their relationship to the main idea” (Cited in Trimble, 1985, p. 18). This definition shows that Trimble’s rhetorical techniques are similar or correspondent to Wilkins’ semantico-grammatical categories.

Figure 3 below shows the rhetorical elements in a larger scale called “EST Rhetorical Process”.

Level	Description of level
A.	*The objective of the total discourse* EXAMPLES: 1. Detailing an experiment 2. Making a recommendation 3. Presenting new hypotheses or theory 4. Presenting other types of EST information
B.	*The general rhetorical functions that develop the objectives of Level A* EXAMPLES: 1. Stating purpose 2. Reporting past research 3. Stating the problem 4. Presenting information on apparatus used in an experiment - a) Description b) Operation 5. Presenting information on experimental Procedures
C.	*The specific rhetorical function that develops the general rhetorical functions of Level B* EXAMPLES: 1. Description: physical, function, and process 2. Definition 3. Classification 4. Instructions 5. Visual-verbal relationships
D.	*The rhetorical techniques that provide relationships within and between the rhetorical units of Level C* EXAMPLES: I. Orders 1. Time order 2. Space order 3. Causality and result II. Patterns 1. Causality and result 2. Order of importance 3. Comparison and contrast 4. Analogy 5. Exemplification 6. Illustration

Figure 3. EST Rhetorical Process Chart by Trimble (1985, p. 11).

The following diagram is an illustrating example of the rhetorical process. It shows how each level is employed in the preceding level in order to fulfil its role in the text. (Levels C and D represent rhetorical functions and rhetorical techniques respectively).

Level A: Describing an experiment
Level B: Previous related experiments Level C: Physical description Level D: space order
Level B: Describing an apparatus Level C: Instruction Level D: Causality and result

Figure 4. An Example of the Rhetorical Process

1.3.2.1. The Rhetorical Functions

A rhetorical function (level C in the chart) means "what a given unit of a discourse (some finite piece of text) is trying to do" (p. 12). That is to say, what purpose and use this piece of text possesses. For example, a paragraph can be written or used to provide a definition of a concept or a description of an object (similar to Wilkins' (1976) categories of communicative function shown above).

In EST discourse, there are five functions which are the most frequently occurred ones. They are as follows:

- The first and most frequent and also the most important one, since it is widely used and essential in scientific and technical texts, is *description*. The different sciences and technological fields make use of description in almost all the activities which are performed in them, such as describing a phenomenon, an apparatus or tool, an experiment, a procedure, etc. It has three distinct types: 'physical', 'process' and 'function' description. Each of these types provides readers with different kinds of information. (pp. 20-71)

- The second function is *definition* which is also common in EST texts. It can be 'simple' as it can be 'complex' depending on the number of sentences and ideas mentioned. Scientists employ this function in many places in their writing especially when they deal with new concepts, ideas and objects as well. (pp. 20-75)

- The third one is *classification*. It has two types regarding "the direction" which means whether an item is classified into a larger group or the class to which a given item belongs is tracked and found. The other type is whether the classification is "explicit or implicit", i.e., it is shown as clear classification or it is understood and implied in the text. (pp. 20-85)

- The fourth is *instructions*. This type is usually found in technical and medical discourses such as manuals of machines and leaflets of medicaments. It can also be used in laboratory instructions in science and in peer writing discussions in scientific journals. It is mainly "telling someone what to do and how to do it to achieve a certain goal" (pp. 20-95).

- The fifth function is *visual-verbal relationships*. It is the part of the text -verbal- that comes with a visual aid, such as graphic displays, schemas and charts, in order to explain its function. It should provide the readers with details about *when*, *where*, *what for* and *why* they should look at the visual. This part of the text and the visual it comes with can be "separated" or the verbal makes part in the visual (pp. 21-102). This piece of text is usually called the legend as in tables and figures.

1.3.2.2. The Rhetorical Techniques

A rhetorical technique (level D in the chart) is "the frame into which writers fit their information" or it is "the way in which the items of information chosen relate to one another or to the main subject of the given unit of discourse" (p. 12). More precisely, the rhetorical techniques are the "elements that bind together the items of information in a piece of EST discourse" (p. 18).

Trimble (1985) distinguishes two different types of techniques: *orders* and *logical patterns*. Orders or "natural patterns provide the framework for the items of information". These natural patterns are: **time order** (*dates; now, then, ...*), **space order** (*above, below, 1mm to the left, ...*) and **causality and result** which are more or less similar to the semantico-grammatical categories provided by Wilkins (1976) stated above. They are called natural orders because "the nature of the material determines the framework that material is put into". In other words, the material being dealt with in the context imposes the outline or the structure to be used by science writers. (pp. 19-53)

On the other hand, logical orders, that “indicate the relationships between those items of information”, are not natural but chosen by the writers to determine the relationships between the presented pieces of information. That is to say, the writers decide or select which structure (logical order) to use unlike the natural orders. The most frequent logical patterns in EST discourse are:

- *Causality and result*: this relationship appears in the natural as well as the logical orders. It is though logical when the cause or the result or both of them are not natural. It can be expressed by means of the following expressions: *thus, therefore, as a result, causing, etc.*
- *Order of importance*: it is preferred to order ideas from the most important to the least important ones. Sequencers (*first, second, third, etc.*) can be used to express the degree of importance.
- *Comparison and contrast*: these relationships show similarities and differences (respectively). They are expressed using: *in comparison, similarly, likewise; in contrast, however, nevertheless,* etc.
- *Analogy*: it is also a comparison but basically of ‘dissimilar’ concepts. It uses expressions like: *by way of analogy, analogically,* etc.
- *Exemplification*: it is the use of examples in order to clarify meaning using *for example, for instance, etc.*
- *Illustration*: it is usually about the visuals used with the text in order to illustrate or explain some concepts in the text. The rhetorical technique called illustration does not represent the visuals but it represents the text used to refer to the visuals, such as: *as figure 1 shows, see table 3, etc.* (pp. 53-54)

Each of the previously mentioned devices, whether it is a grammatical category or a rhetorical technique, once used does not exclude any of the other devices. The same with functions, they may overlap in a way that a unit may have a function and the larger unit that contains it may have a different function. For example, a description of an instrument may include a definition of one component of the instrument. The same description might employ time, space and causality and result in addition to exemplification.

1.4. The Scientific Writing

The writing style depends in some cases on the writers and in other cases on the content being written or dealt with. Academic writing takes the content as priority in its style; no personal interference is accepted. The scientific writing style is one instance of academic writing which fully and completely depends on the content. This is due to the fact that what is said and done in science is very important and influential not only for the scientists but also for the whole world. For that particular reason, science writers are always advised to use only necessary words, make every word worth using and keep it as concise and accurate as possible.

Thus, the nature of the information presented, i.e., scientific facts, led the scientific writing style to have special features. Some of these features are to be detailed because of their significance for science writers and readers as well.

In order to clarify more the nature as well as the characteristics of the scientific writing, the scientific writing is compared with literary writing. Both styles can be considered opposites regarding their nature, subject and audience.

1.4.1. Characteristics of Scientific Writing

The scientific writing differs from other types of academic writings in a set of specific criteria. This difference goes back to the nature of the content; science, which requires to be precise and clear. As explained by Silobrcic (1998), the nature of the content determines the features and the style of the writing. He mentions that “the characteristics of a scientific writing style derive from the intention of communicating scientific information”. Exactness, trustworthiness and conviction are some of these characteristics. (Cited in Vainre, 2011)

Earlier on, Ransom (1977) states an effective set of criteria of scientific writing. Science writers can think of these criteria during the process of writing or while they are revising their papers. It is as follows:

1. If it can be interpreted in more than one way, it’s wrong.
2. Know your audience; know your subject; know your purpose.
3. If you can’t think of a reason to put a comma in, leave it out.
4. Keep your writing clear, concise, and correct.
5. If it works, do it. (Ransom, 1977. Cited in Harris, 1997, p. 463)

Even formerly, Bloomfield (1939a) summarises the key features of scientific prose that make it special. These features are mainly economy of language, precision, effectiveness and objectivity. He writes that:

> The use of language in science is specialised and peculiar. In a brief speech the scientist manages to say things which in ordinary language would require a vast amount of talk. His hearers respond with great accuracy and uniformity. The range and exactitude of scientific prediction exceed any cleverness of everyday life: the scientist’s use of language is strangely effective and powerful. Along with systematic observation, it is this peculiar use of language which distinguishes science from non-scientific behaviour. (p. 1)

Similarly, Huth et. al. (1994) states that “effective scientific prose is accurate, clear, economical, fluent, and graceful” (p. 101). Fluent and graceful in this context mean easy and understandable but not decorated. Each of these criteria is quite significant in scientific writing and thus should be taken into consideration by writers. *Precision* is quite important in order to avoid ambiguities which cause confusion and may prevent readers from grasping crucial aspects of the methodology and synthesis. *Clarity* is essential because most of the concepts and methods in science can often be complex; language must not add to this complexity. *Objectivity* is in the heart of scientific writing because any claims should be based on facts, not intuition or emotion.

Another list which provides simple, yet reliable, details about each of the most significant characteristics that help science writers achieve a good form of the scientific text is that put by Blake (2010). He explains what makes each of the features important and how it is able to help writers. A good scientific writing then is:

-*Clear*: it avoids unnecessary detail;

-*Simple*: it uses direct language, avoiding vague or complicated sentences. Technical terms and jargon are used only when they are necessary for accuracy;

-*Impartial*: it avoids making assumptions (Everyone knows that...) and unproven statements (It can never be proved that...). It presents how and where data were collected and supports its conclusions with evidence;

-*Accurate*: it avoids vague and ambiguous language such as about, approximately, almost;

-*Objective*: statements and ideas are supported by appropriate evidence that demonstrates how conclusions have been drawn as well as acknowledging the work of others. (p. 10. [emphasis added])

In addition to science writers, all the above-mentioned features are crucial for readers as well because when reading a scientific text, they are looking for scientific information and not for the beauty and sophistication of the language. That is what scientists should put in their minds when writing their papers for publication. Goldbort (2001) emphasises that they “must present their findings as clearly, concisely, and rigorously as possible”. The text should focus on the content and the information being presented because the readers “expect the emphasis to be on understandability and evaluation of the information rather than on the ‘elegance’ of the words themselves” (p. 23). Therefore, to make the text clear, concise, and rigorous, the language used must be simple, precise, and direct.

On the other hand, Marin-Arrese (2002) explains that these criteria of scientific writing are of a great importance not only to the readers but also to the scientists themselves so as to best present their findings. She mentions that “the pursuit of the universal generalisation in scientific texts enables the author to signal credibility, objectivity, reliability and ultimately authority to their readers and the research community”. The more the text is clear and precise, the more the content gains validity and trueness. There is no place in science for the dress-to-impress idea.

Most importantly, Huttner-Koros (2015) explains that what makes the scientific English with these specific characteristics is the same reason why the English language is the language of science and technology in the first place (to be stated further in this chapter). It is essential for science writers to know that there are “clear and exact features” of scientific texts that help the target audience understand the content without worrying about the “vagueness, expectations and imbedded meaning” which might be created by the language. (p. 5)

Wills (2016) has studied the benefits of these specific characteristics of scientific writing for writers for they help them address the potential audience taking into account all types of audience possible. These characteristics “do not only allow peers to scrutinise scientific studies and efficiently share information, but they also demonstrate a degree of expertise for the publishing scientist to other audiences, such as academics and the general public” (p. 642).

1.4.1.1. The Economy of Language

Bloomfield (1939a) mentions that in science, writers should deliver their findings with the least number of words possible -and accepted. This factor is called the ‘economy of language’ which means using less and effective words instead of too much talk around the intended idea. Fortunately, English, unlike other languages such as French and Arabic, offers this feature.

Matthews, Bowen and Matthews (1996) explain the notion of ‘economical’ or the economy of language saying that “verbal fillers in spoken English have no place in scientific writing”. They have given the following examples of this problem and how it can be removed or avoided:

The first choice should be replaced by the second:

‘It would thus appear that’ becomes *‘Apparently,’*

‘It is possible that the cause is’ becomes *‘The cause may be,’* and

‘In light of the fact that’ becomes *‘Because.’* (p. 115. [emphasis added])

According to Day and Sakaduski (2011), all scientists “must learn to use the English language with precision”. The best way to achieve this as they have suggested is that scientists who write and publish their findings must know how to present these findings with ‘exactness’ and ‘correctness’ in which the information will be direct and understandable (p. 4). There is no need in scientific writing in English for too much wordiness to explain a single idea; one simple, clear sentence can do the job.

1.4.1.2. Clarity

An important feature of the scientific writing is being clear. It is the advice of the editors and examiners of scientific and technological journals. An example is in the Instructions to Authors Ecology (1964): “Write with precision, clarity and economy. Every sentence should convey the exact truth as simply as possible" (Cited in Benson, 2014, p. 185). Ambiguity and reading between lines are not quite accepted in scientific prose.

Likewise, Katz (1985) explains how the clearness of a scientific text can be achieved. He says: "each sentence must convey a definite idea, and it must have an unequivocal interpretation". That is to say, there should be "no mystery, no vagary, and no intimations of unwritten meanings or of arcane knowledge". Readers will be looking for knowledge not for puzzles to solve. In order to achieve this extent of clarity, Katz advises scientists to "use simple, direct words, words with little emotional weight and clear meanings". This makes the scientific texts, unlike other types of texts, have less words but more value. (p. 15)

Unquestionably, clarity is the aim of scientific writing. The primary objective of scientific writing is mainly conveying the scientists' thoughts and findings to the reader in a clear and economical way. The nature of the scientific research requires precision and this precision is reflected only with clarity. Therefore, a good scientific writing style achieves the goal of providing the audience with unambiguous comprehensibility of the content it presents. So, a good scientific text is that which succeeds in making the readers forget about the language and care only for the content. (Ford & Peat, 1988; McMillan, 1988; Eriksson, Altermann & Catuneanu, 2005)

Day (1998) stresses the importance of clearness as "the key characteristic of scientific writing" because the reader of science expects a level of difficulty due to the content itself, and thus the language, as a 'tool' should help in clarifying the information and not the opposite (p. 1). If scientific data are not clearly presented, they cannot be understood because "good science is the most important thing; but the science needs to be clearly understandable" (Cargill & O'Conner, 2009, p. 105).

All the points discussed so far show that the language is a means that is used to convey meaning, not to change it with decoration. Any decoration or attempt to add beauty to the text can change the ideas presented and create a different meaning which leads to misinterpretation of concepts. In science, this can be a disaster. In this vein, Gocsik (2015) notes that "it is not important when writing a scientific paper to be eloquent. It is absolutely important, however, that you be clear".

1.4.1.3. Objectivity

One more important criterion of the scientific writing, that is a core element of both the content -science- and the discourse, is being objective or impersonal. In other words, the writer should not appear in her/his papers and different productions by use of words such as: *I, me, my opinion, etc*. There should be no sign of the author in her/his texts and "the facts speak for themselves" (Swales, 1990, p. 112). As Gilbert and Mulkay (1984) notice in examining research papers, what really matters in reporting "experimental data" is "chronological as well as logical priority". Thus, there is no place for "the author's own involvement with or commitment to a particular analytic position nor his social ties with whose work he favours are mentioned" (p. 56).

Despite the fact that the content of a scientific paper is determined by the actions and interference of the scientist, "such papers are overwhelmingly written in an impersonal style, with overt references to the author's actions and judgements kept to the minimum" (Gilbert & Mulkay, 1984, pp.56-57). In other words, the scientist is a neutral participant in the scientific activity s/he is carrying out and that is how s/he should be in communicating this activity in the form of articles, dissertations or reports.

The scientist should not be known or shown in her/his texts because scientific experiments must have the same results if done by any other scientist. Daston and Galison (1992) say that "the ideal observer has no particular characteristics which interfere with the transmission of the results or the comparison between results obtained in a different place, at a different time and by different researchers" (p. 87).

Objectivity in science is a value that tells how science was anticipated and how the presented scientific truths were discovered. Therefore, it is revealed in scientific writing which should be free from particular perspectives and opinions, value promises, community bias and/or personal interests and preferences that might be implied by the writer (Sokal & Bricmont, 1999; Mulder, 2014). When the scientist says "*I* have created the chemical X in *my* laboratory", he can give the impression that only *him* can make it and in *his* own laboratory only. This leads the shared results to lose their credibility and the whole work to no longer have the notion of duplicity (being able to be repeated by any other scientist).

Equivalently, Douglas (2004) explains that scientific activities deny any interference of the scientist stating that "science is objective in that, or to the extent that, the processes and methods that characterise it neither depend on contingent social and ethical values, nor on the individual bias of a scientist" (p. 454). The only interference of the scientist is reporting her/his experiments and findings. Any other personal or social factor may lead to ambiguity, and thus to wrong interpretation of the data presented.

In this vein, Chang and Swales (1999) find out that "warnings against use of first personal pronouns were universal" particularly in science writing. The use of personal pronouns reduces the objectivity of the text. These warnings come first in almost all Style Guides of writing and publishing in science (p. 145). Therefore, a call for impersonality in scientific writing is not a yesterday-born idea. Throughout the twentieth century, science teachers in schools and universities liked to insist on an 'objective' or impersonal style to express scientific ideas. Above all, in reporting experiments, students were told to: (1) avoid the first person, for fear of appearing purely subjective; and (2) use the passive voice, to make the report seem more impersonal (‘*a flame was observed*’ is preferred to ‘*I saw a flame*’). In order to achieve objectivity and impersonality, Hamalainen (2006) suggests to (1) use the third person tone instead of the first person; (2) avoid emotional expressions, for example, instead of writing: “*Students suffering from dyslexia*”, write: “*students who have dyslexia*”; and (3) get rid of implied or irrelevant evaluation. (p. 4)

Similarly, Yurkiewicz (2015), in guiding science students who are willing to write and publish, states that the use of personal pronouns violates the nature of science which is being objective. As advice, “it strongly recommends against using anything that could bias language, such as first-person accounts, descriptive adjectives, or anecdotes”. The reason is that “this is science, and science should be objective”.

An example that illustrates the difference between objective and subjective writing is that presented in a lesson given by University of Leicester (2015). Objective language is neutral language that states a fact or process; however, subjective language is exposed to question or interpretation as it involves personal thought or belief. For instance:

- Objective: *The car travelled at 38 kilometres per hour*

is a clear, objective statement of fact. However:

- Subjective: *The contents of the test tube turned a beautiful blue colour*

uses *beautiful* in a way that is subjective because it cannot be measured or accurately explained to the reader.

1.4.2. Scientific Vs. Literary English

The difference between scientific and literary writings is that they emphasise different features of meaning. The purposes for using these two kinds of language are also different. The purpose of using the scientific writing style is practical which is describing the physical world. However, the purpose of using literary language is to share the author’s emotion, attitude and feeling. Poetry is a good instance of literary writing. As an example of different purposes, a text in literature can be used to tell a story from the past, a text in science is used to present facts that can change some universal concepts.

Jameel (2012) outlines the main differences between scientific and literary writings and the reasons or intentions behind these differences as follows:

> Scientific language is devoid of any sensuous pleasure whereas literary use of language is full of human impulse and human pleasure. Scientific words differ from ordinary and literary words since they do not accumulate emotional associations and implications. Scientific language is supposed to be more direct, free from alternative, and much less artistic than literary language. (p. 51)

That is to say, scientific and literary writings are contrasting because they have different purposes. As stated by Evans and Rooney (2014), "writing in science is very different from literary writing. Scientific writing has one objective: to communicate information. Literary writing has a second objective: to entertain" (p. 325). In other words, scientific writing intends to present, communicate, explain and clarify a given phenomenon or concept; however, literary writing can present information as well but not with the same degree of seriousness and trueness in addition to being mostly for entertainment. Novels, stories and also magazines are some instances of the latter objective.

Consequently, what is employed by literary writing may not be used in the scientific prose. Trimble (1985) insists that scientific writing should be far from the emotional factor. It is concerned with stating facts (or hypotheses); emotions do not fit in science communication. EST writing "does not, for example, make use of such rhetorical functions as editorialising, non-logical argumentation, poetic images, or those functions that create emotions such as laughter, sadness, etc." (p. 14).

Correspondingly, Krauss and Chiu (1998) declare that “there is a lot of evidence that scientific English has distinctive features” which make it different from some types of writing but not all. There are some “language patterns and rhetorical forms which may be common in science may also be used frequently in other forms of academic writing” (p. 42). Writing in the humanities is an example of this share; however, literary English escape it.

From a different perspective, the scientific writing differs from any other type of writing due to the nature of the content. Cargill and O’Conner (2009) explain that “what seems clear is that for science writing there is a divide in the way people think about the content -the science- and the way they think about the language used to express the content” (p. 105). This reason can be caused by the place and role of the language to the content; writing in science “differs somewhat from that pertaining to writing in the humanities and social sciences, where the language is seen to form the argument, and therefore the content of the writing” (p. 105). The language for scientific context is an ‘additional’ factor or a tool of communication only. However, in humanities, it makes part of the context and sometimes as important as the content.

It is clear then that what makes these two styles (scientific and literary) totally different is the demand of the content of each type. Science is concerned with facts and literature allows emotions and fiction (most of the times). Jameel (2012) states that “the scientific use of English is marked with accuracy, precision and objective interpretation of facts and findings whereas literary language is subjective interpretation of life”. He further explains the reason stating that “literary language contains literary impulse and represents the artist’s inner self and his spontaneous overflow of feeling whereas scientific language represents universal truth and verifiable research findings” (pp. 48-49).

This view leads to mention an important and remarkable feature that marks the difference between the two types of writings which is *impersonality*. Unlike literary writing style, scientific writing is known of its impersonality because the seriousness and significance of science and the facts or theories it presents necessitate the notion of duplicating or checking the work. Ding (2002) clarifies that "by impersonalising, the author implies that there could have been anyone, or any research could have been carried out, the research still would have come to the same conclusion" (p. 158). In contrast, in literature and by the interference of the writer and his emotions, feelings, way of thinking, own perspective and own interpretation of ideas, the work is neither required to be repeated or checked by others nor it is even made to be believed or stated as fact. Even if it is repeated by others, each person has his own touch and each work or idea can be seen from a different angle.

Another distinctive feature between scientific and literary writings is the use of decoration or decorative language. Literary writing is known of this factor. Most of the time, it employs different techniques in order to impress the reader such as metaphor, idioms, figures of speech, etc. On the other hand, scientific writing avoids completely the use of such techniques because the content demands clarity. Thus, the beautification can mislead the reader in searching for information. As Goldbort (2006) puts it, "the beauty of science is in the science, not in the language used to describe it". However, the beauty of English (i.e., the power or the capacity) "is its ability, when properly used, to express the most complicated concepts in relatively clear words and to point up the beauty of the science". In other words, the language that communicates science successfully "involves that magic word, clarity, a kissing cousin of simplicity" (p. 9). An utterance in literary texts might be explained in several different ways; however, in science, it should mean exactly what it says and only what it says.

In the same line, Day (1998) asserts that “scientific writing is the transmission of clear signal to a recipient. Scientific writing needs no ornamentation”. The decorative language leads to confusion, ambiguity and multiple interpretations for readers. The style employed by poets and literature authors such as “flowery literary embellishment-metaphor, similes, and idiomatic expression” are expected to cause confusion and lead to imaginary interpretation. Therefore, it should not be used in scientific papers. (p. 2)

1.5. Writing with Audience in Mind

Science in the past used to be the interest of scientists and science students only. Science and technology further became the interest of businessmen and trading companies because they are considered an important source of money and financial supplies. At the same time, different sciences attracted media and many televisions are making a huge business from them (documentaries, high-tech advertisements, etc.). Today, the audience of science and technology expands to reach almost everyone in the world; not only scientists, inventors and entrepreneurs but also social and public groups and individuals.

Audience proved to be a chief factor in the business of writing and scientific writing in particular. The importance of audience in scientific writing is gained due to two main reasons which are the universality of science on the one hand and its communication on the other hand. English as a language, as well, won its position as the language of science and technology due to the concept of audience (in addition to some other reasons).

1.5.1. Universality of the Scientific Writing

The universality of science led to the universality of scientific communication. Science is spread all over the world; the new discoveries and developments in the different fields of science and technology lead to the growth of the audience of science. Christophorou (2009) states that “the advancement of science has been unimaginable and the scientific frontier is endless” (p. 1). Science becomes the interest of not only scientists but other social groups as well; it attracts several types of audience such as businessmen and curious people. That is why communicating science becomes of great importance to the whole world.

As stated earlier, scientific facts or theories presented by scientists in the form of experiments, investigations or observations are subject to be checked and repeated by other scientists in the world. Science needs to be valid and gain credibility. That is why almost all scientific findings should be accessible and reachable by any person in any place. It is about "ensuring that science is trusted and valued [as well as accessible] by societies across the world" ("International Council for Science". Cited in Paty, 2001, p. 310).

Scientific communication won this universality due to other features that are not only related to science but to its characteristics as well. According to Widdowson (1979), the scientific text is a specific "realisation of a universal mode of communication". The scientific text makes use of "a number of non-verbal devices which are used in any language such as tables, graphs, and diagrams" (p. 45). These non-verbal elements are universal and do not belong to one language in particular which is one reason why science communication is considered universal.

In addition to that, a universal communication is a crucial condition to achieve universality of science; science and its communication have influence on each other. Christophorou (2009) states that "a prerequisite of the universality of science is freedom of work and communication in science", i.e., any person can try science and share what s/he finds. These two factors guarantee the "opportunity for every nation and every generation to participate in, and profit from science" (p. 2). Science is for everyone.

Furthermore, Christophorou (2009) indicates that "science is universal in at least two fundamental ways". The first way is about the global features of science which are mainly (1) "the applicability and validity of its method" which -when certain conditions are prepared- can be done anywhere, (2) "the generality of the physical law" which is true everywhere in the world and (3) "the effects of scientific knowledge on human functions" that is science is important in humans' life and in their activities. The second way is "the participation of humankind in it" which is seen in the countless contributions from all over the world as well as the great demand to learn how to communicate in science (p. 1). (This is shown in the growth of learning English as the language of science as to be stated further.)

Proving the universality of science and universality of scientific communication causes a demand for a universal language of science. For several reasons, English happens to be this universal language.

1.5.2. Why English

During the past two centuries or so, English has been considered the lingua franca of the world; not only in the field of science and technology but in business and economy as well. This is shown by the number of publications in English in these fields. In matter of statistics and according to Baldauf (1986), the International Federation on Documentation (FID) -a world body which keeps track of information distribution- reported that nearly 85% of all the scientific and technological information in the world today is written and/or -at least- abstracted in English. Swales (1990) has studied carefully the dominance of the English language on different sciences in addition to other fields. He finds that "English continued to be by far the most important language of publication (75%)". Other languages were coming far behind with a percentage less than 5%. (p. 98)

Similarly and in more recent statistics, this percentage has increased to become more than 90%. Hamel (2008) notices that "more than 75 percent of the articles in the social sciences and humanities and well over than 90 percent in the natural sciences are written in English" (p. 53). This number confirms that English is the first choice in terms of importance and dominance in different fields of science.

Rao (2014) highlights the position of the English language in science and technology stating that English is "overwhelmingly dominant in scientific and technological communication with all relevant and ground-breaking information". English has developed in a continuous and fast pace to become the main "means of communication" in the different fields of engineering in particular and in conclusion, it gained a "huge advantage" over other languages that were on top of the list once. (p. 2)

As a matter of fact, the dominance of English refers to the number of publications in science written in English. In the opinion of Blackwell and Martin (2011), this fact is a reason and a result in the same time; i.e., on the one hand, the number of publications in English helps it become the language of science, on the other hand, scientists publish in English because it is the dominant language. Therefore, scientists who want to publish their works and findings in an international level must write their papers in English.

In addition to that, during their studies and investigations, scientists from all over the world are expected to search and read previously published work in their area of interest. It is not practicable or feasible to translate these published papers into their own language. Therefore, one global language should be selected and become the language of science in order to facilitate the access to these papers. In other words, scientists' need for reading in an international language contributed to the dominance of English on different fields of science. As Remache (2013) puts it:

- over two-thirds of the world's scientists read in English.
- (more than) half of the world's scientific literature is written in English. (p. 38)

English thus becomes more than just a language. It becomes an important means of communication, not only in science and technology, but in all types of discourse as well.

Thus, authors and scientists in particular are advised to write and publish in English if they want their articles to reach a large audience from all over the world; if not, people who speak different languages will most probably not bother translating these articles into English or their language.

Then, it is better to write directly in English because translation is not always possible nor it is convenient. The text may lose its real value if it is translated. Thus, scientists must acquire English as an additional skill to their scientific mastery so that they can read and write. Yashroy (2013) demonstrates that the "language plays a major role in readership scientific and research articles. Translation and editorial help are limited". The importance of English as a means of communicating science in the world reached the extent that "many good workers remain unnoticed because of deficiency in English".

Swales (1990) indicates that "there is no doubt that English has become the world's predominant language of research and scholarship" (p. 99). However, there are some exceptions to this predominance. The nature and the content of the fields which escaped the dominance of English are the main reasons behind these exceptions. Thus, it can be "hypothesised that research fields relying on localised input (archaeology, agriculture, literature, religious studies) are more likely to resist or escape the domination of English than those do not (chemistry, genetics, physics, etc.)" (pp. 99-100).

Supporting this idea, Hamel (2008) has tracked the language of most publications in different sciences during the last century. He finds out that "throughout the 20th century, international communication has shifted from a plural use of several languages to a clear pre-eminence of English, especially in the field of science" (p. 53).

As results of the dominance of English, other European languages lost their places and became the second choice of scientists especially those willing to publish in international journals. Ammon and Carli (2007) write the following notes:

-English has constantly made gains as a language of science over the past fifty years.

-English is the sole working language of the European Science Foundation (which coordinates research projects in EU countries and elsewhere.)

-The leading European scientific journals now tend to prefer English as their language of publication. (p. 55)

Relatedly, Huttner-Koros (2015) compares between the languages of past major work publications in science and recent ones. He states that “Newton’s *Principia Mathematica* was written in Latin; Einstein’s first influential papers were written in German; Marie Curie’s work was published in French”. However now, most scientific researches around the world are published in one standard language: “English”. He found out that English took the place of these languages (in addition to others) even in the countries where they are the native languages. Based on statistics, “English is now so prevalent that in some non-English speaking countries, like Germany, France, and Spain, English-language academic papers outnumber publications in the country’s own language several times over”. As one of the most extreme examples *the Netherlands*, English to Dutch ratio is “an astonishing 40 to 1” (p. 5).

Kaplan (2001) says that “it is an established fact that progress in science depends on the accumulation of a written record of all previous science; that science requires information storage and retrieval systems” (p. 11). Such systems are a universal language and a standard frame; for the language, English got that role.

On the other side of the coin, English won this position not only due to the number of publication but also due to some political and economic facts and events that the world witnessed in the current as well as the previous century. The political and economic power and dominance gained by the United States of America in addition to the history of glory of the United Kingdom together with some other past actions are some examples of these events. In Crystal's (1997a) words:

> The WWII settlements and the birth of the United Nations, the invention of the computer, and the geometric growth of science and technology, all occurring coincidentally at the same time, created the conditions which made English not just an important language but the predominant language of science and technology. (p. 20)

Kaplan (2001) mentions reasons that are more or less similar to the aforementioned ones including the Industrial Revolution in Europe and the wars that came after; they caused the world to become dependent on science and technology (the industry of machines and weapons). The United States had its share in this, too, "by virtue of the fact that its scientific infrastructure was undamaged by the war" regarding its land which was geographically far from the wars (p. 10). This fact led the U.S.A. to attain leadership in most science and technology domains.

Gordin (2015) has shown a different thought based on facts that go back to previous centuries. More than one hundred years ago, no one could have thought of one language to be the dominant language of science or any other field. It would be "a mixture of French, German and English" because at that time, there were scientific publications (mainly books) in different languages; most of them were in the three mentioned ones.

Salehi, Khadivar and Mehrabi (2015) support this idea because it is part of the complete truth that English had not always been the dominant language. Latin, Greek then French and German were also dominant languages in the past. Another example was the Arabic language which had its share in some period of time. Jean Auel in her book series *Earth's Children* (1980) mentions that "during the great expansion of Islam, Arabic was carried to the furthest corners of the known world" and it was the language of all sciences. (Cited in Ammon, 2011, p. 9)

Similarly, Salehi et al. (2015) have traced the languages that had power and leading role in science. Before English, *Latin* "was a dominant language in science. Then, each scientist used to publish in his own language". For example, Galileo had published in Italian. Later, Latin vanished and no longer existed. In order to keep the recorded science before World War I, all the scientific publications were "equally divided between French, German and English". After the war, German lost its position and became limited and thus not acknowledged. Consequently, French and English took over (temporarily). The U.S.A., on the other hand, put a law that restricted or prevented the use of German. Because of this law, the "Americans reduced their exposure to foreign languages". Soon afterwards, the American isolationism which occurred in the 1930s subsequently led to the dominance of English over the scientific publications in the world.

In addition to political and historical facts, Economic factors also lead to this dominance of the English language. Graddol (2006) have a different thought concerning how the English language gained this status in science and technology. Teaching English to international students is of great demand in the English-speaking countries, especially the U.S.A., UK, Canada, etc., which produces a great contribution to the economy of these countries.

As summed up by Tardy (2004), accepting and considering English as the universal language of science is "due in part to historical, political and economic factors which favoured English over other potential candidate languages such as Chinese, French, German, Russian, or Spanish" (p. 247). Despite the fact that English is not the most or the first spoken language in the world like Chinese and Spanish, these factors helped English to dominate.

1.6. The Role of Audience in Research

English is an international language and its importance leads people to use it around the world. The dominance of English on the different branches of science and technology, as shown above, enlarges the audience of published papers in these fields. Science is not the interest of scientists only; all kinds of people are interested in new discoveries and changes science does to the world. Chemistry, as an example, is known as the science of magic and it has a considerably large audience of all types and ages in the world.

This enlargement in the audience of science makes it of great importance in the writing process. In other words, writers, especially scientists, must put in their minds the concept of audience during writing and before publishing. They are not writing to peers only; there are other parties that are not experts in the same field but are interested to know what is new in it such as science students.

1.6.1. The Nature of Audience

Moffett (1968) has expressed a view of audience based on "an interrelationship between the writer, subject, and reader". Any type of communication includes two relationships: how the writer views the subject or the content, which he calls the "I—It" relation, and how the writer views the reader, which he calls the "I-you" relation. In other words, audience is as important as any other considerations of the writer and the content s/he explores. (p. 244)

Similarly, Anson (1992) points out that "the audience is not separate from the discourse and its social context". It should be considered as a crucial part of the writing process because if the audience is recognised, its "values and needs" can be identified and thus the text will be as clear, understandable and interesting as possible. (p. 69)

A writer’s audience is different from a speaker’s audience. The speakers, in most if not all cases, are able to see and know their audience or listeners. However, the writers cannot recognise what audience they might have. Elbow (1998) argues that “not paying enough attention to audience is a problem inherent in the nature of writing itself” since they are physically absent (p. 177). Therefore, writers are advised to expect, imagine or consider audience according to the subject or content of what they are writing. They must post their ideas as clearly and accurately as possible by “paying lots of attention as they write to their audience and its needs” (p. 177). Audiences for scientists are real people (experts, peer scientists, science students, etc.) whom they should know during the writing process, and even beyond. Despite this fact, Blakeslee (2001) states that “audiences are complex, dynamic entities that can never be known completely, and thus, of necessity, entail some level of abstraction, they are also real entities that can be addressed and made more concrete and discernible” (p. 50). That is why the concept of audience is the subject of many researches now and in all types of discourse, writers and speakers are recommended to think carefully about it.

This paradox caused confusion for scientists in particular about who exactly the audience is. Blakeslee (2001) suggests a solution by which scientists can think of all possible types of audience who might read their papers. The advice says that “it may be much more productive to think of authors’ understanding of and approaches to audience as resting on a continuum someplace between imagined and real, rather than as being exclusively one or the other” (p. 50). It means know who the real audience is and imagine who else can possibly be. This consideration helps them write and express their ideas as clear as possible.

Therefore, during the process of writing, the writer may ask the following questions suggested by Clark (2003). These questions help scientists either identify who the exact audiences are or imagine who they can be:

- Who is going to read this?
- Who cares about this topic?
- How have you considered your audience? (p. 141)

What scientific writers should put in mind is that the audience, whoever reads scientific publications, is used to think that whatever said or published by scientists is completely true believing that these scientists cannot be wrong and the information presented cannot be fake truths. Yearley (2005) notices that “trust is central to the business of science” (p. 122). The trust is the view of the reader towards the writer. Hence, the writer must take that into consideration in the presentation of her/his work.

Moreover, the relationship between the writers and the readers is not simple; it is rather a complex one. Even if the writers find out who the readers can be, still it is not easy to write for these known readers. Writing, as Kroll (1984) puts it, is considered “as a process of conveying information, a process in which the writer’s goal is to transmit, as effectively as possible, a message to the reader”. Nevertheless, this view is partial in that it does not show the position of the reader in the construction of the text. Writers then must realise that “filling a reader’s head with information is not nearly as simple as filling a glass of water. Writing is not simply encoding, nor is reading simply decoding” (p. 176). In other words, both writers and readers have an essential role in the building of good knowledge (even though the credit should go back to the writer -researcher). In science communication, audience became a key part. Writing requires “knowledge of the purpose of your work as well its intended audience, expertise and knowledge of methodology, and last but not least a good style”. (Milas, 2005. Cited in Vainre, 2011)

1.6.2. Types of Audience

The concept of audience is known and clear; however, the exact audience cannot be easily identified. For the same piece of writing, there might be more than one type of audience. Elbow (1987) says that “there are many different entities called audience” (p. 50). Kroll (1984) examines three types of audience that are: “the rhetorical, the informational, and the social” (p. 178). Peers are the rhetorical audience, informational means who needs information like students, and the social audience is the general public interested in the subject being discussed and presented. Scientific work has all the three types as its audience. When it comes to science, the first audience to put in mind is peers (peer is a person who is equal in abilities, qualifications and background). Prelli (1989) declares that “scientists choose the issues they address and then persuade their peers that those issues are significant” (p. 144). Peers are experts or referees who are supposed to approve the work and their role is very important in the business of science. When scientists have direct feedback from these peers (such as experts of publishing journals) their benefit increases. The ‘interactions’, whether direct comments or written remarks and notes, “reveal the negotiations, uncertainties, disagreements, and messiness”. Audience is thus a “central concern in scientific problem formulation” (Blakeslee, 2001, p. 24). In other words, if scientists know who they are writing for and understand their needs, they will definitely improve their writings.

Still with scholarly journals in which audience has now become *audiences* as put by Clark (2003). It comes with a set of ‘complex’ qualities including “invoked, evoked, fictionalised, intended, or general” (p. 142). For example, the audience of scientific papers used to be only peers; i.e., the editors of the journal where the author is willing to publish, which still is the first audience for a scientific article. Later, science gained larger audience starting from students to general public who like to stay updated with new discoveries in the different fields of science and technology.

Clark (2003), further, presents another classification of audience. Two types can be distinguished in the writers' mind: whether the audience is real and known or it is unreal and imagined. Therefore, writers can manage to know their audiences and by taking them into consideration, they can address them appropriately. A practical advice that can be given to science writers is that considering the appropriate and exact audience depends on the writer's "concept of audience within the communicative act". That is to say, either the writers believe that they are actually communicating with real, known readers, or they -instead- "create roles for a broader, unfamiliar audience by providing audience-oriented textual cues". (p. 143)

For that reason, Ong (1975) considers that "audience is always a fiction" for writers in particular. The writer such as "the historian, the scholar or scientist, and the simple letter writer all fictionalise their audiences, casting them in a made-up role and calling on them to play the role assigned" (pp. 10-12). This fictionalising trick helps the writers explain their thoughts, ideas and findings clearly and accurately.

Belinda (2016) has come up with a different thought. Science audience is better known than imagined, i.e., writers should not imagine their audience, they should rather know it. Audience is an essential concept in the writing process; therefore, "it has seldom been conceptualised in relation to imagination" (pp. 1-2). As for science, audience is known; not fully but at least generally speaking. Science writers then must always put in their minds that there are three main types of audience of science which are: peers, science students and the general public. When it comes to post-graduate science students, audience might have two main types: first, the journal's board of examiners who are going to examine their articles and willing-to-publish papers. Second, the scientific community which they should convince with the new scientific facts and arguments that they provide in their research.

Audience is then determined by writers and/or by the content of the work presented. The characteristics of scientific writing, which are mainly precision, clearness and correctness, are caused by the existence and awareness of the existence of audience. Bultitude (2011) shows that scientific prose is meant to achieve all types of audiences including not only peers but non-peers as well. Science communication exceeds the ancient notion that it is a “one-way communication of knowledge from scientific experts to public audience”. (p. 1)

The different types of audience -mainly three- may cause the scientific text to have three types as well. In Widdowson’s (1974) words, the “scientific text can be classified into three types”. If it is directed to peers who have similar, shared knowledge, it is considered as “a discipline”. If it concerns teachers and students of science and found mainly in textbooks, it is “a subject”. If it attracts ordinary, general people such as journalists, layman, etc., it is then “a topic of interest”. (p. 130)

1.6.3. The Importance of Audience

Audience has been very important in writing and speaking since the ancient times. For example, Plato in the *Phaedrus* (370 B.C. trans. by Jowett 1892) emphasises the importance of taking into consideration the audience in writing and speaking. He declares that “the rhetorician should adapt a speech to characteristics of an audience, classifying the type of speech appropriate to each type of soul” (Cited in Clark, 2011, p. 110). Aristotle, as well, emphasises this importance saying that “in writing as in talking in public; you may think that audience is important to consider for those who speak in public, but it is as important in writing or may be more”. The reason is that “you can’t see who you are writing for" (Cited in Aristotle, Ross & Smith, 1963, p. 425). This makes writers more careful and cautious with audience than speakers.

In the modern world, the concept of audience did not change. Cargill and O'Conner (2009) indicate that it is helpful for scientists to know their audience providing the question: "Whom do you see in your mind's eye as the reader of what you are writing?" (p. 14). Goldbort (2006), previously, emphasises this importance declaring that "it is not enough, then, for effective and responsible scientist-writers to know their subject. They must also know a document's readers". He suggests different questions which science writers have to ask about their readers:

> How much do they know about the subject? Is the document for a research supervisor, a journal, a public official? How should a document's technical formality and style be adjusted for its reader(s)? Do the writer's intentions match the reader's expectations? What would the reader expect? (p. 6)

Earlier on, Booth (1983) reaches the extent that audience, if not appropriately studied and considered, may cause the written text to lose its value. The "rhetorical stance", as he calls it, is "what makes the differences between effective communication and mere wasted effort". This stance controls the balance between the "three elements" that must be present in any writing process; they are "the available arguments about the subject itself, the interests and peculiarities of the audience, and the voice, the implied character, of the speaker". (pp. 139-140)

Selzer (1992) shares a similar view of audience and its position in the construction of texts. He states that the three components "writer and audience and text are inextricably patterned in the creation of meaning through discourse" (p. 173). In other words, to have a clear, complete meaning that can be considered as a significant contribution to knowledge, the writer, as one part himself, must pay attention to audience and the content he discusses -as the other two parts- as well as the relationship between these three parts.

However, all the responsibility to make the work meets with success lays on the writer. As Gopen and Swan (1990) report, “if the reader is to grasp what the writer means, the writer must understand what the reader needs”. Therefore, writers, especially in science (because they are dealing with important issues), should recognise “the fundamental purpose” of the scientific text which is not a simple presentation of facts and ideas, but it is a real “communication”, in which the receiver of information has a similar position as the writer and the text. In other words, writers must not consider that writing is only converting “all the right data into sentences and paragraphs”. What really matters is “whether a large majority of the reading audience accurately perceives what the author had in mind” (p. 550). Scientists’ awareness of their potential audience “pushes authors to stronger, more effective arguments”. That is why they must acquire the skill that allows them to “target and appeal to their audiences” in order to be able to “persuade and gain adherence and support for their ideas” presented in their papers from the targeted audience. (Blakeslee, 2001, p. 12)

The more writers think of their audience the more they enhance their writings in matter of clarity, argumentation, style and presentation. Vainre, (2011) insists on writers to “keep the purpose and audience of the text in mind” through asking the questions: “who will read it?” and “why will they read it?” Writing with audience in mind proved to be more efficient than writing without thinking about the audience. Belinda (2016) studies the impact of the awareness of audience on writing and found that “the focus on audience in process writing pedagogy has met with mixed success” (p. 3).

Accordingly, awareness about the audience affects other aspects of a text, such as purpose, form, style, and genre. As an instance presented by Clark (2005), if the audience is peer, then “scientists may omit necessary explanations, definitions, or support, because they assume, quite reasonably, that their peers are already familiar with the topic and, therefore, do not need such information” (p. 10). If the audience is general public or students, such explanations and definitions are necessary and required.

The role of audience in science changed from merely believing whatever was put and presented as facts to becoming part of the whole writing process. Recently, scientists “cannot be trusted to tell the truth about controversial and technological issues”. They have to expect suspicion from whoever reads their papers, and thus they must provide thorough explanation and use more convincing arguments (Schiele, Claessens, & Shi, 2012, p. 237). Therefore, science writers must be “particularly aware because readers of science-related writing can have very different levels of knowledge”. Readers of science are not only scientists, they can be general -curious- people, especially in the present time. That is why science writers should always ask the question: “Am I writing for fellow scientists or for a general audience?” (Peer-to-peer; peer-to-non-peer) because what the readers know or do not know about the subject “will have a significant effect on both substance and style”. (Plotnick, 2014, p. 1)

For the case of NNS science students (of interest in the present research), the most important audience for them is peers, as the examiners of their papers and future scientists and science students. However, they must expect their papers to be rejected, not because of the content but because of the language.

Conclusion

English for science and technology is concerned with teaching English in the light of learners’ needs. If these learners are non-native speakers of English, the difficulty of learning to read and write scientific texts increases. For that reason, in this chapter, the major characteristics of scientific writing were stated. In addition, some reliable comprehension devices were underlined for they are seen to help NNS students have better access to scientific and technical texts. In order to have a better scientific communication, the role of audience in writing was highlighted, drawing attention to the reasons that make English the dominant language of science and technology.

In this chapter, the researcher tries to shape a theoretical background for science students that will enhance and boost their ability to read and analyse scientific texts, and thus remove the language barriers and have a direct access to the information needed. It will also help them strengthen their capacity to write such texts and have their work and findings reach the intended audience.

The general characteristics of scientific writing in addition to the position of English in the communication of science are not the only necessary details that should be considered by science writers. Aspects of the language such as grammar and lexis are of a great importance too.

Chapter Two

The Scientific Article

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The Scientific Article

Introduction

The scientific article is a widespread published academic paper. Like all the researchers in different fields of science and technology, Algerian students of science have to write scientific articles at the end of their researches. The scientific article is considered the fruit of the scientific work, which allows sharing the accomplished findings and the formed knowledge with the scientific community and the entire world.

This chapter provides practical definitions of the scientific article and highlights its major characteristics. It also presents the necessary details that might provide writers of scientific articles with a general idea about the nature of this type of papers so that they know what it requires to write it and have it accepted and published in international journals. This is followed by an explanation of the importance of writing a scientific article at different levels. A comparison between scientific articles and other types of academic papers is also given. This is expected to help science students and writers understand the status of these papers and their role in the world of scientific research.

The chapter also includes a presentation of the format and the sections that constitute the scientific article. In addition, it highlights the significance of the structure of the scientific article and states the main details to be put in each of its parts.

2.1. The Scientific Article: an Overview

The scientific article is a specific kind of academic -published- paper. It aims to present a new contribution to the scientific research and the most recent work in a particular field of study by providing an original observation, investigation or discovery in a certain domain of science or technology.

Todorović (2003) defines the scientific article as “a written and published report describing original research results” (p. 203). He further explains that a scientific article must contain the necessary amount and type of information to enable other scientists: “(1) to assess observations, (2) to repeat experiments, and (3) to evaluate intellectual processes” (p. 203). In other words, the scientific article must provide all the details of an investigation that permit the scientific community -particularly peer scientists- to check the originality of the contribution, evaluate the work and test the results.

The scientific article is the means through which scientists present and deliver the recent discoveries and experiments in science to the whole world. According to Hewings (2006), the research article is “the most important channel for conveying claims of new knowledge” (p. 12). It is through articles, original scientific and technological knowledge and discoveries reach the interested audience and the whole world.

Additionally, Johnson, Mikos, Fisher and Jansen (2007) mention that writing a scientific article is “to construct a clearly written document that describes a question and then logically presents an answer to this question that is based upon theoretical or experimental results that were done before” (p. 2728). Science is known for the risen questions and hypotheses through observing the world and the attempt to answer these questions by experimenting and reasonable testing. The scientific article is designed to share those enquiries together with their solutions in order to answer human’s curiosity. Therefore, the scientific article is considered an indication and proof that a scientist has carried out a research work or an experiment, and that her/his work succeeded as an original, creditable and worth-sharing achievement. As Peh (2007) puts it, “a published article is indisputable evidence of research that has been performed, completed, and accepted by peers” and then published to be shared with the scientific community (p. 55).

Moreover, a scientific article is one type of research papers where an original study has been carried out. This study is usually a combination of a review or comparison between previously published studies in the same field and/or freshly performed experiments. A scientific article is a paper, which reports the methods and results of an original study performed by the scientist(s). This study can be an experiment, survey or interview. Yet, collecting and analysing data to find results is the method followed in each type of the scientific study.

In highlighting the scientific article as an original and typical paper, Aparasu (2011) considers it as a "peer-reviewed" and presents a complete description of a new research finding, and typically follows a standard format. He explains "peer-reviewed" as a necessary process before publishing the article, which "helps ensure that published results are scientifically valid and grounded in evidence" (p. 12). That is to say, this process confirms that the information presented by the scientists are facts and stated with objectivity. Thus, the scientists cannot include their own opinions, attitudes or wishes.

Additionally, Day and Gastel (2012) define the scientific article, in light of its constituting parts, as "a particular kind of document containing certain specified kinds of information in a prescribed (IMRAD) order" (p. 20). IMRAD stands for Introduction, Methods, Results and Discussion, which are detailed further down.

Similarly, Jeyaraj (2014) defines the scientific article as "a well-written scientific paper [which] explains the scientist's motivation for doing an experiment, the experimental design and execution, and the meaning of the results" (p. 1). These details constitute the major parts of a scientific article, which are *the purpose of the study*, *the methodology of the research*, *the findings* and *their discussion*.

Furthermore, Hengl and Gould (2002) consider the scientific or research article as "a technical document that describes a significant experimental, theoretical or observational extension of current knowledge, or advances in the practical application of known principles" (p. 1). On the basis of this definition, one can recognise the most common types of a scientific article. Therefore, a scientist can write a scientific paper to describe an experiment, collect and analyse previous related theories or simply explain an observation about new phenomena or existing facts. However, all these details can appear in one -typical- article.

An important aspect to take into account is the audience. It is a chief factor in science writing (cf. chapter one). The significance of the audience leads to highlight the importance of publishing. A scientific article cannot achieve its purpose unless it is published. Jenkins (1995) explains that "publication in a reputable, peer reviewed journal should be the goal of every researcher, as this provides the most effective and permanent means of disseminating information to a large audience" (p. 285). Publishing the article is the last step in the writing process and it is as important as the other steps. Without publication, the scientific article cannot reach its goal, which is informing the audience of science about the new achievements and discoveries.

Therefore, writing scientific articles is the most common way of communicating the results of an investigation to other scientists. This communication of science is meant to reach the general public as well which increases the responsibility and duty of the scientist, as disseminating findings and sharing knowledge in science is carried out through publishing (Docherty & Smith, 1999).

Although writing and publishing an article is the final work presented by scientists, it is the summary of a research, an experiment or a comparison study. In other words, it is not the first step in the research process; much work has to be done before writing the article. Tischler (2014) says that the scientific article is "a written and published report describing original research results" (p. 3), i.e., after observing, researching and experimenting, the scientific article is written to inform science audience -of its different types- of the results and findings of the complete research.

Based on the concept of publication, the scientific articles are published papers in scientific, peer-reviewed journals which Björk, Roos and Lauri (2009) name “Scientific Journal Papers”. They define it as “a paper which describes scientific research results, which has undergone some form of anonymous peer-review and which is published in a regularly appearing serial, usually by a third-party publisher and not by the university of the author”. This definition highlights the publishing side of the article; it must be reviewed and discussed in order to gain creditability and then published to reach the potential audience. Furthermore, concerning the types of publication, they have stated that the article is particularly used in nature sciences and medicine, unlike other domains such as computer sciences where “conference publishing” is common, and in humanities, “books” are preferred and widely used.

Besides, Prokhorov (2010) accentuates the importance of publication. He mentions that “a scientific study is considered to be incomplete until its results recorded in written form for dissemination” (p. 688). He states that “publication of a scientific work is essential in cases of a question concerning the establishment of scientific priority” which determines the details to be included in such papers.

Similarly, Doumont (2011) highlights the importance of writing and publishing articles in science calling these two processes: “The Communication of Science”. He sees that this communication is essential to both the scientists and their audience. Thus, writing and publishing are essential part of the research a scientist performs. The article serves as a “gauge of scientific productivity”. Published scientific articles provides a “long-lasting body of knowledge from which other scientists can build their research”.

From a different perspective, Brownell, Price and Steinman (2013) present the significance of publishing scientific articles saying that “scientific experiments are demanding, exciting endeavours, but to have an impact, results must be communicated to others” (p. 7). Based on this view, they define the scientific paper as “a method of communication, an attempt to tell others about some specific data that you have gathered and what you think those data mean in the context of your research” (p. 7).

In a nutshell, the main purpose of a scientific article is to inform and convey the recent findings and achievements in the different domains of science. This purpose is attained through publication. That is why writing and publishing an article are considered chief skills and also responsibilities of scientists, and thus they make important parts of their activities.

2.1.1. History and Emergence

The nature, content and layout of a research article evolved through time. This evolution is due to the change in how science is discovered, experienced and evaluated, as well as how it is communicated. Swales (1990) explains that in the process of this development “the scientist’s relationship with nature gradually changed from a view that the nature of things would be easily revealed by direct or manipulated observation to a view that nature was complex, obscure and difficult to get at” (p. 113) which requires deeper examination and analysis to be understood. For instance, observing the colour of objects in nature is simple and direct; while looking for the causes of the appearance of one colour over the others in a particular object is complicated and needs more than mere observation to be exposed.

This evolution in dealing with science led to a change in reporting science. In the past, it was enough to report the observations and the results. Today, it is more important to thoroughly describe how the experiments were carried out, why choosing such or such a method or material, and what resulted from these experiments. The reason behind this change, in the opinion of Swales (1990), is that “minor differences in procedure could produce major differences in findings” (p. 113). Recently, communicating science demands that every step of the experiment must be clearly presented and detailed because any tiny change in the details may cause the experiment to have totally different results.

Before the appearance of articles as they are known today, laboratory reports were published to share the results of the scientific activities carried out by scientists. These reports included every single detail of what happened in the laboratory. These reports were similar to the ‘experimental essays’ described by Boyle. Both types were published but the essays used to follow a particular order and include certain types of data. The order was as follows: (1) “the reasons for undertaking a certain experiment”; (2) “a step-by-step account of the methodological procedures used in the experiment”; and (3) “the presentation and discussion of the results arrived at, often leading to the formulation of new hypotheses” (Cited in Wortman-Wunder & Kiefer, 2012).

The reports and essays are developed into articles in order to match the content and meet the audience. Describing the experiment with all its steps in addition to placing the results into their context, taking into consideration the fact that science is no longer directed to scientists only, are the main reasons of the emergence of articles. Fahnestock (1986) has studied “the fate of scientific observations as they pass from original research reports intended for scientific peers into popular accounts aimed at general audience” (p. 275). The enlargement in audience determined the way science is communicated and changed the means of communication and type and amount of data that should be presented.

Similarly, Wortman-Wunder and Kiefer (2012) explain that scientific papers were developed from simple notes and remarks of the scientists to articles that present the results of experiments and discoveries. They have mentioned that the “scientific paper has developed over the past three centuries into a tool to communicate the results of scientific inquiry”. This evolvement aimed to facilitate the placement and finding of data presented.

The results are the fruit of the scientific work and the most important information that need to be shared within the scientific community. For that reason, Day (1998) declares that the aim of the development of the scientific paper was to present the results ‘appropriately’. He says that “scientific research articles provide a method for scientists to communicate with other scientists about the results of their research” (p. 38). *Appropriately* means that what was done and how it was done must be clearly and accurately presented and explained.

A question that needs to be raised here is: *Why is it important to present and explain how the results were obtained*? The answer to this question lies in the fact that there is a necessity to test the results. It means that the audience of scientific papers (peers and non-peers) demands to know all details about the methods through which the findings were attained in order to be able to check and value what was achieved. As Alley (1996) explains, the main goal of scientific articles is “to present data and/or ideas with a level of detail that allows a reader to evaluate the validity of the results and conclusions based only on the facts presented” (p. 5).

Moreover, the development of research articles in science and technology does not include only the information and details presented but includes the layout as well. The format of a scientific article evolves and changes in order to manage to present the necessary data. The main reason for this evolvement is to enable the readers to easily find the type of information they are looking for. Booth, Colomb and Williams (2003) mention that in scientific articles the information is presented in “a clearly structured format making use of sections and headings so that the information is easy to locate and follow” (p. 115).

That is to say, with clear-cut components making use of sub-titles and headings, readers can directly find the sort of information they are searching for whether it is the methodology followed or the results obtained.

Correspondingly, the organisation of ideas in a clear style and layout is crucial for readers to understand what is being communicated. Tischler (2014) accentuates the importance of clarity in organisation saying that “scientific papers are written in a style that is exceedingly clear and concise” (p. 3). Such a clarity must appear in the language, the style, how the ideas are presented, how the purpose of the work is stated and how the results are explained and discussed.

2.1.2. Characteristics of the Scientific Article

A scientific article is, then, a published paper, which presents recent achievements in science. The characteristics of a scientific article are more or less similar to those of science itself on the one hand, and to those of the scientific writing on the other hand.

The first and most required features in reporting science are validity, originality and importance. A scientific article cannot be accepted and published unless it contains new acknowledged facts that are important in the particular field it discusses. Accordingly, Gordon (1983) states that:

> It is important to emphasise that a research article should report on research findings that are not only sound (valid) and previously unpublished (original), but also add some new understanding, observation, proofs, i.e., potentially important information. (Cited in. Hengl & Gould, 2002, p. 1)

As discussed earlier (cf. Chapter One), clarity in addition to objectivity are quite significant features in the communication of science. The nature of science demands to be clearly presented and independent from the writer’s identity. Therefore, Docherty and Smith (1999) insist that “authors -of scientific papers- should at all times have in mind objectivity, clarity and honesty in reporting their research" (p. 1224). These features can be achieved with impersonality and neutrality.

Communicating science in a clear and simple way is as important as the content being presented. A scientist might present a new worth-telling discovery in science but, if it is not presented clearly and accurately, it may lose its value. Carpenter, Walker, Anderies and Abel (2001) indicate that "it is not enough to simply have a good idea. You must be able to communicate it clearly" (p. 765).

Similarly, Hengl and Gould (2002) point at the fact that some science authors may tend to use a more complicated style, which contains plenty of technical words and compound sentences. This might be due to their willing to sound scientific or because they are used to such a style. However, "the editors (and probably the readers) prefer simple, clear and coherent writing, rather than a fancy or complex, pseudo-scientific style" (p. 6). Science is already difficult.

Moreover, the main reason behind the demand for clarity in writing scientific articles is that one scientist's work can start a channel of further works. It is explained by Doumont (2011) that articles are "critical to the evolution of modern science, in which the work of one scientist builds upon that of others". Therefore, to make that possible and accessible, "papers must aim to inform, not to impress. They must be highly readable — that is, clear, accurate, and concise".

In the same vein, Peh (2007) considers that writing scientific articles is not only for "the communication of a finalised piece of research", it is also "the basis for further opinions, views and critiques from fellow professionals and academics" (p. 55). He insists that every scientist must acquire the skill of writing research articles during their studies because these articles represent "the only permanent record of scientific work that has been completed" (p. 55).

Similarly, Shah, Shah, and Pietrobon (2009) state that “clear communication of the findings of research is essential to the growth and development of science and professional practice” (p. 511). Many researchers and experiments become possible to be carried out because other experiments were done and some methods were tested. The thorough explanation of these experiments and methods is what made this possible.

It is important to mention that the characteristics of a scientific article are not only important for the authors but for peer-reviewers and journal editors as well. Hoogenboom and Manske (2012) provide a summarised list of the criteria that should be taken into consideration by both writers of the articles before submitting their papers for publication and the journal reviewers:

> (1) the importance, timeliness, relevance, and prevalence of the problem addressed; (2) the quality of the writing style (i.e., that it is well-written, clear, straightforward, easy to follow, and logical); (3) the study design applied (i.e., that the design was appropriate, rigorous, and comprehensive); (4) the degree to which the literature review was thoughtful, focused, and up-to-date; and (5) the use of a sufficiently large sample. (p. 513)

In general terms, the purpose of writing articles in clear, precise and exact way is to enable the science community (peers and professionals) to check the validity of information presented. The language should not make a barrier. Brownell, Price and Steinman (2013) explain that scientific papers must be written clearly and concisely in order to enable readers, who share similar backgrounds, to understand straightforwardly what has been done and how it has been done and also to see whether they can repeat or extend the work being presented.

Likewise, the paper should be in a clear set and layout with clear language that the audience can find information easily -no ambiguity, clear-cut between ideas, less effective words and sentences. The advantages of writing clearly are: Firstly, for the scientists in order that they can transmit their ideas and findings exactly; and secondly, for the audience so that they can easily find and understand the information and facts. Clearness in language and style should reach an extent that the reader will not bother himself with decoding difficult and complicated language but with the content itself. In other words, the content is presented in way that the reader does not notice the writing. The ideas flow into their heads and make sense, the topic is interesting and they follow along the paper. ("*A guide to clear language and layout for the key investor information documents*", 2010)

2.2. The Specificity of the Scientific Article

A scientific article is different from other types of published papers. The differences do not appear in content and shape only, but in the procedure followed to be written as well. Some language aspects, such as tense occurrence and word choice, are distinguished either. The first factor that makes scientific articles unique is their layout. The specialised structure it has (i.e., IMRAD) causes a difficulty to NNS science students who are not familiar with writing scientific articles in English as stated by Lewiston (2011), "the scientific format may seem confusing for the beginning science writer due to its rigid structure which is so different from writing in the humanities" (p. 1).

In order to solve this confusion, students must be aware of the differences in shape, content, language and writing process. If they become aware, they will be pay more attention to such factors while constructing their scientific articles, and thus, they will improve their performance (writing). Tischler (2014) suggests that "understanding how these two types of papers (Humanities and Sciences) differ in the type of research done, the purpose of writing and the style of writing, it will make writing a scientific paper much easier" (p. 3).

The second factor, which causes a scientific article to be different, is the content: Science. Science demands a specific language (cf. Chapter One) and requires a specific procedure to be communicated as well. That is why writing a scientific paper follows certain 'rules' that "are rigid and are different from those that apply when you write an English theme or a library research paper" (Brownell, Price & Steinman, 2013, p. 2). Therefore, writers of scientific articles (students or scientists) must understand that they are not writing to entertain readers but to inform them.

2.3. The Format of the Scientific Article

2.3.1. History and Background

The scientific article is a unique published paper because of its special format. The layout of an article usually depends on the type of research done: theoretical, experimental or observational. However, the big majority of articles published in nature sciences have followed the IMRaD format. The acronym represents the first letters of the sections: Introduction, Materials and Methods, Results, and Discussion. The American National Standards Institute (ANSI) had adopted the term IMRAD as the standard format of scientific articles, "first in 1972 and again in 1979". Thus, it has become the choice of most research journals in America and then in many other countries (Cited in. Nair & Nair, 2014, p. 13). Reviewers and editors of scientific papers in most popular journals have the lion's share in the extensive use of the IMRAD structure. The purpose, as Huth (1987) puts it, is "to benefit readers and to facilitate the process of peer review" (p. 626). Readers would be able to straightforwardly find the information they need and reviewers would understand the flow and connection of the presented data.

In addition to that, this structure enables the authors to present the findings of their researches "in an orderly, logical manner" (Day, 1998, p. 39). This logical way demanded the article to be organised in this order: "Title, Authors, Introduction, Materials and

Methods, Results (with tables and figures), Discussion, Acknowledgments, Literature Cited". However, this is not necessarily the order in which authors did their study or even wrote it. They may start with *Results and Discussion*, and then write *Introduction* and *Conclusion* (Day, 1998, p. 39).

As stated earlier, scientists are obliged to accurately describe how their research and/or experiments are done. This description is presented in the Methods section. However, the method only is not enough; the scientists must present some related theories in order to place their work in its domain. They must also explain the findings of their research. In this context, Atkinson (1999) states that "method description increasingly developed during the second half of the nineteenth century, and an overall organization known as '*theory—experiment—discussion*' appeared" (p. 340. [emphasis added]).

In the past, scientists used to publish only their observations and results without a need to explain how these results were found, what they meant or how they could be used and applied. However, as the audience of science widely enlarged, the type of shared knowledge changed and increased. The scientific community -including peers- demanded to be informed about the method(s) by which the findings were obtained, in addition to the explanation of these findings. The appearance of the scientific article as it is known today which is due to "development and changes in the internal organization" is, as Meadows (1998) puts it, "an answer to the constant growth of information" (Cited in. Sollaci & Pereira, 2004, p. 370).

Therefore, the reason which led to a standardised format for scientific articles is "to provide a systematic and organised way to present the data" (Docherty & Smith, 1999, p. 1224). Science writers, then, are not free to present their work the way that suits them. Specific data and information are required and should be clearly demonstrated. Therefore, the articles formed about observational and experimental researches are typically "divided into sections with the headings: Introduction, Methods, Results, and Discussion" (Docherty & Smith, 1999, p. 1224). In some cases, the article may require sub-sections in some of its parts.

It is imperative to mention that the format sometimes depends on what the journal requires. Some journals demand a particular structure and specific headings. For example, *Science* journal oblige authors to include "an abstract, an introduction, up to six figures or tables, sections with brief subheadings, and about 40 references. Materials and Methods should be included in supplementary materials, which should also include information needed to support the paper's conclusions" ("*Instructions for authors, Negative Results*", n.d.). Still, almost all journals, especially in medical and nature sciences such as chemistry and physics, follow the same order: IMRAD. Carpenter et al. (2001) state that in most sciences, "the layout of a scientific article is fairly consistent" (p. 768).

As mentioned above, this standard format is a recently established one. The scientists were free to demonstrate their researches in the way they liked. The published scientific papers that existed in the past were *letters* and *experimental reports*. Both forms had no particular organisation but depended on the authors' style. The letters were, as Sollaci and Pereira (2004) state it, "written in a polite style, and addressed several subjects at the same time" (p. 364). Earlier on, Ard (1983) explains that "the genre of the scientific article developed from the informative letters that scientists had always written to each other". The first form of science communication in the past was 'letters' that were exchanged between peer scientists. These letters contained the observations of the scientists in their laboratories during the experiments. Later, they contain description of how the experiments were carried out. Those letters were further published in order to reach more scientists of the same field (Cited in Swales, 1990, p. 110). This led the letters to evolve into 'descriptive' reports, which developed also into "a more structured form in which methods and results were incipiently described and interpreted" (Sollaci & Pereira, 2004, p. 364). Eventually, the letter form disappeared. In other words, the scientific article has developed in shape and text from "purely descriptive style in the seventeenth century to a very standardised structure in the twentieth century" (Sollaci & Pereira, 2004, p. 364).

Accordingly, a standard format (IMRaD) became the choice of science writers and many journals not only because it is a smooth, simple organisation of the article for both writers and readers but also because "this format allows the paper to be read at several different levels" (Lewiston, 2011). For instance, readers may have a glance at *Titles* and *Abstracts* to see if the topic interests them. Others may go deeper and check the *Results* and *Discussion* sections if they decide (from the *Title*) that the article is useful for them. That is to say, whatever the section the readers check, they will understand the research done and its main results.

Generally speaking, every member and aspect involved in the research process; from the author, peer-reviewers and editors, the nature of science itself, and the entire scientific community with its specific requirements; made part of the evolvement of the format of scientific articles. All these elements led in one way or another to the establishment and application of the IMRaD layout as a standard presentation of the content of scientific articles. The following figure (Figure 5) shows an instance of choosing the IMRaD format over other formats by a European scientific journal:

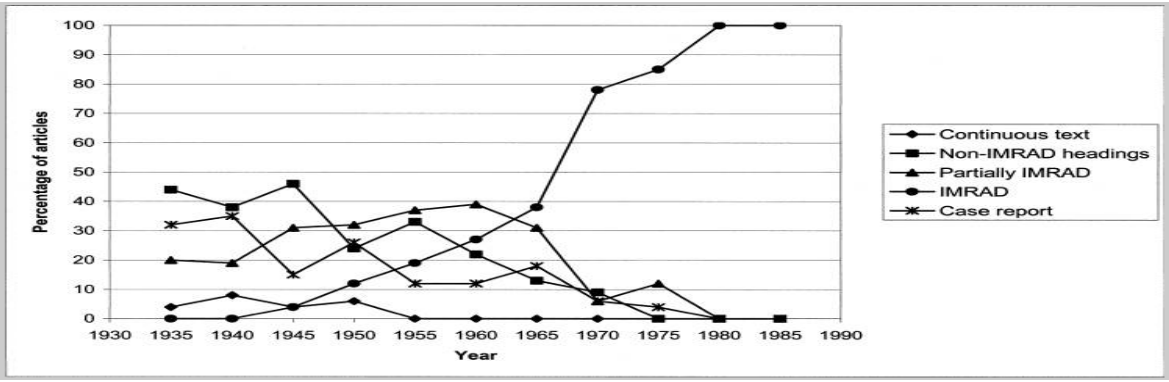

Figure 5. Text Organization of Published Articles in the *British Medical Journal* from 1935 to 1985 (n = 341) (Sollaci & Pereira, 2004, p. 368)

Furthermore, the essential details and type of required knowledge also helped in the creation of the standard format of the scientific article. According to Jameel (2012), the IMRAD format is followed by all the scientific journals as far as medical and natural sciences are concerned. This format is the most suitable and acceptable structure in which an article can reach its goal which is mainly informing the scientific community and the general public about the recent achievements in science. Thus, this format can manage to detail the required information. The author summarises background information along with previous related findings in the *Introduction.* He explains the procedures used in his research in the *Methods and Materials* section. Then, he presents the findings and observation accomplished from the work with the use of tables and figures in the *Results* section. At the end, he interprets the meaning and importance of these results in the *Discussion* section.

From all the points discussed so far, it can be said that this particular typical layout -IMRaD- does not only represent a group of sections or titles included in an article. It indicates, as put by Nair and Nair (2014), “a pattern or format rather than a complete list of headings or components of research papers” (p. 13).

2.3.2. The Importance of a Standard Format

In writing usually, it is useful to follow a plan in which ideas are organised. The same with scientific articles, there is a big quantity of ideas and data that need to be well organised in order to be appropriately interpreted. For that reason, it is imperative to have a model or specific layout by which scientists can easily express their findings and results. A scientist would rather care about what to present than how to present it. However, the shape of the article is as important as its content. Therefore, one standard format can solve this problem.

A standard format is important for readers as well because readers of scientific articles do not usually read the whole article or simply said, they do not read it in the order it is written or presented. They may start with the Abstract, then scan the Results and later check the Methods, and so on. As stated by Meadows (1985), The IMRAD structure "facilitates modular reading" which is different from -usual- reading from the beginning to the end. Readers may have a glance at each section of the article, looking for specific type of information, which is usually found in recognised locations of the article. (Cited in. Sollaci & Pereira, 2004, p. 370)

Similarly, Jones, Bizzaro and Selfe (1997) explain that readers of scientific articles in particular "have relatively fixed expectations about where in the structure of prose they will encounter particular items of its substance" (p. 144). Thus, this helps writers, if they are consciously aware of this fact, to better control the level of emphasis a potential reader will give to the several pieces of information being presented. They continue to say that "good writers are intuitively aware of these expectations; that is why their prose has what we call '*shape*'" (p. 144). For instance, if readers want to know how the experiment was done, they will read the Methods section. However, if writers keep changing the structure of their articles, "readers are forced to divert energy from understanding the content of a passage to unravelling its structure" (p. 144).

Accordingly, scientists -when writing their articles- should put enough details under each heading; enough for the readers who may jump between sections. However, they should not make each part a separate unit; it must rather be linked to the rest of the paper. For that reason, Jenkins (1995) advises scientists to "consider the manuscript as telling a story", arguing that this helps to sustain steadiness and continuousness between the main sections of the article (p. 286).

Therefore, the organisation and order of information in the scientific article is as important as the content itself. Hoogenboom and Manske (2012) insist that scientists should “be thoughtful about the distinction between content (what you are reporting) and structure (where it goes in the manuscript)” (p. 512). They have to bear in mind that “poor placement of content confuses the reader (reviewer) and may cause misinterpretation of content” (p. 512). Arbitrary distribution of data or carelessness about the place of each piece of information will not serve the writer or the reader.

Likewise, Hengl and Gould (2002) declare that articles “require good skills in both structuring and phrasing” (p. 1). The content can be misunderstood, misinterpreted for being unintelligible if it is not presented in a well-organised structure. Thus, even if the ideas and results are good and interesting, the article “will be rejected if the style and format of the paper are not tailored for the audience” (p. 1).

It can be concluded that both the content and the format share almost the same degree of importance for science writers and readers. A good idea can be misinterpreted if it is not appropriately presented. The opposite is also true; as stated by Johnson et al. (2007), “a poor idea or a poorly designed investigation cannot be saved by an excellent presentation of the work, and equally an excellent idea that is well investigated can still be doomed by a poor presentation” (p. 2827).

Consequently, a standard format of scientific articles acts as a reading pattern like in simple essays. It is essential for readers in general and science audience in particular to know that scientific articles are written over a certain pattern, which is always the same. Being aware of this standard pattern helps them have direct access to the information being presented (Biparva & Shooshtari, 2012). One structure enables them locate the type of information needed -whether they want to understand the procedure: in Methods section, or to know the findings: in Result and Discussion.

Moreover, as an additional reason, which contributes to the importance of publishing scientific articles within a standard structure, Lester and Lester (2015) state that writing articles following the IMRAD format "makes uniform the numerous articles written internationally by millions of scholars" (p. 22). This suggests that all published scientific articles will have the same outline, and this is an advantage for the audience of science and technology.

2.4. Components of the Scientific Article

As shown above, the scientific article functions better if it follows a standard layout. This layout, as many journals and scholars agree, is the IMRaD format, which stands for: ***I**ntroduction*, ***M**ethods and **M**aterials*, ***R**esults* and ***D**iscussion*. However, the article must comprise other section to fulfil its objective such as: *Title*, *Abstract*, and *Literature Cited* or *References* (Ambrose & Ambrose, 1995; Carpenter et al., 2001; Hengl & Gould, 2002). Accordingly, two types of the sections of the scientific article can be distinguished: Essential sections and Additional sections. The additional sections as listed by Hengl and Gould (2002) are: "Author-paper documentation, Keywords, Acknowledgements, Abbreviations and Appendices" (p. 3).

Lewiston (2011) provides check-list questions that help the writers to know and understand the general idea and the type of information to be put in the paper and in which section it goes. These questions are in Table 1 below:

Table 1. The General Idea of Each Section of the SA

Experimental process	Section of Paper
What did I do in a nutshell?	Abstract
What is the problem?	Introduction
How did I solve the problem?	Materials and Methods
What did I find out?	Results
What does it mean?	Discussion
Who helped me out?	Acknowledgments (optional)
Whose work did I refer to?	Literature Cited
Extra Information	Appendices (optional)

Note. From Lewiston (2011, p. 10).

In order to simplify the process of writing, Doumont (2011) considered scientific papers like essays; the main components are *introduction*, *body* and *conclusion.* Articles that report experimental research are structured in the following sections: The *Introduction*; *Materials and Methods*, *Results*, and *Discussion* (which make up the body of the paper); and the *Conclusion*. On the other hand, Borja (2014) presented an interesting outline of a research article in which all the components of scientific articles are mentioned. This outline is as follows:

General Structure of a Research Article

Title
Abstract
Keywords
Main text (IMRAD)

Make them easy for indexing and searching!

(informative, attractive, effective)

Introduction
Methods
Results
And
Discussion

Conclusion
Acknowledgements
References
Supplementary Data

Journal space is not unlimited.

Make your article as concise as possible.

Figure 6. Structuring an Article/Parts of a Research Article (Borja, 2014)

2.4.1. Title and Abstract

The Title and Abstract are essential components in scientific articles because they briefly provide all the key details. Most readers read only these two parts in order to decide whether to complete reading and whether the article is useful for them or not. For that reason, it is not easy to write them; thus, writers should take the following points into consideration:

- they are the only parts of the paper that are read by many readers, and often the only parts that are freely available;
- they have to summarise the study and be fully understandable without the rest of the paper;
- they must be short;
- they must show that the study has novel aspects. (Blackwell & Martin, 2011, p. 14)

2.4.1.1. The Title

The Title is the identity card of the article. It tells what the article is about, which subject it addresses and what is studied and why. It is important for scientists to think of a title that makes readers know and understand the topic of the article.

2.4.1.1.1. Background

Jenkins (1995) states that the title "provides the first impression to the reader, so selecting the most appropriate title requires some thought" (p. 286).

Similarly, Thomas Clifford Allbutt, a British physician and inventor, indicates the importance of formulating the title of a scientific manuscript. He says that "first impressions are strong impressions; a title ought therefore to be well studied, and to give, so far as its limits permit, a definite and concise indication of what is to come" (Day & Gastel, 2012, p. 39). In other words, the essential elements of the research or the article should be clearly indicated in the title in few words.

Similarly, Carpenter et al. (2001) state that the necessary information which should be conveyed by the title of the article are: "its purpose, the results and conclusion" (p. 770). However, writers should bear in mind that it is -still- a title; it cannot be a paragraph. Thus, the essential details must be presented in the title with the least number of words possible.

Likewise, Brownell, Price and Steinman (2013) insist that the title of a scientific article must be "self-explanatory". In other words, the reader can understand the nature and type of the reported work without a need to read the whole paper. This allows them to choose to complete reading the article or decide that it is not what they are looking for. That is why the title is considered as a chance for the writers to draw readers' attention to their work and make them interested in it; according to Borja (2014), "the title must explain what the paper is broadly about. It is your first (and probably only) opportunity to attract the reader's attention" (p. 15).

2.4.1.1.2. Features of the Title

The title of an article must contain the essential words in the correct order in which the subject of the article is accurately and fully expressed. In addition to that, in order for the title to be effective and attractive, it should be related to the purpose of the study. Therefore, in constructing a title, science writers must follow these steps:

1. Include all necessary keywords to correctly and fully convey the content of the study.

2. Delete all words that are redundant or do not contribute to the essential meaning.

3. Order the words to reflect accurately the meaning you intend. (Rudestam & Newton, 2014, p. 318)

Not far from that, Publication Manual of the American Psychological Association (APA, 2010) mentions that the title of manuscripts such as theses, articles and dissertations "should be a concise statement of the main topic". It should briefly "identify the actual variables or theoretical issues under investigation and the relationship between them" (p. 2). Although the title should express or describe the work sufficiently, it should not be so long. It ought to be clear but short and precise. It should concisely reflect the content of the article (Lewiston, 2011; Borja, 2014). It is even proved (through statistics) that "short-titled" articles which describe results have "higher viewing and citation rates than those with longer titles" (Paiva, Lima & Paiva, 2012, p. 510).

Considered from a different angle, titles must be clear enough to help the readers who are searching for a particular type of information. In order to do so, titles should be "comprehensible and enticing to a potential reader quickly scanning a table of contents or performing an online search"; however, they should not be "so general or vague as to obscure what the paper is about" (Strunk & White, 1979, p. 15). As it is mentioned earlier, the Title is what makes readers decide to read the whole article or not.

Moreover, the significance of the Title is related to the audience of the paper. Day (1998) says that the title should be "specific enough to describe the contents of the paper". In order for the paper to reach the intended audience, its title should be "appropriate"; however, it should "not [be] so technical that only specialists will understand" (p. 40). In other words, titles of scientific and academic articles must be clear as Tischler (2014) advises writers because "an improperly titled paper may never reach the audience for which it was intended" (p. 2). A good work or investigation might be lost or skipped if the title does not convey the subject appropriately.

It is important to note that some particular words cannot be used in titles. Day (1998) claims that "titles should almost never contain abbreviations, chemical formulas, proprietary (rather than generic) names, jargon, and the like" (p. 142) taking into consideration the appropriate degree of clarity to reach a larger audience. In addition to these types of words, science writers are advised to make their titles short yet explanatory and to "omit all waste words such as *"A study of …"*, *"Investigations of …"*, *"Observations on …"*, etc." (Tischler, 2014, p. 2. [emphasis added]).

Similarly, Rudestam and Newton (2014) provide some examples of titles that can be problematic and misinterpreted by readers and thus the articles can be misplaced:

> *A study of Information-Processing Deficits of the Authoritarian Personality.*
>
> The phrase "A Study of" is redundant, unnecessary and can be omitted.
>
> *An explanatory Study of the Interrelationship of Loneliness, Obesity, and other Selected Variables Within Two of Bruch's Obesity Subgroups and a Control Group.*
>
> Much too long and cumbersome; no more than about 12 keywords that summarise the main idea.
>
> Better: *The Role of Loneliness in Bruch's Obesity Subgroups.* (pp. 318–319 [emphasis added])

2.4.1.2. The Abstract

An Abstract is considered the summary of the paper. The Abstract should briefly summarise each of the key sections of the article (Jenkins, 1995; Joshi, 2005; Zeiger, 2000).

2.4.1.2.1. Background

The Abstract has to briefly cover the main parts of the research. Figure 7 below highlights the essential points that every abstract must contain.

Figure 7. Main Components of an Abstract (Jenkins, 1995, p. 287)

Statement of:
- -The question asked (present verb tense)
- -What was done to answer the question (past verb tense) – research design, population studies, independent and dependent variables
- -Findings that answer the question (past verb tense) – the most important results and evidence (data) presented in a logical order.
- -The answer to the question (present verb tense)

If useful, and where word limit allows, include:
- -One or two sentences of background information (placed at the beginning)
- -An implication or a speculation based on the answer (present verb tense, placed at the end)

In the same vein, Tischler (2014) states that the Abstract "should succinctly state the principal objectives and scope of the investigation where these are not obvious from the title". The title has almost the same role as the abstract; however, "the abstract should concisely summarise the results and principal conclusions" (p. 2).

From a different view, Brownell, Price and Steinman (2013) do not consider the abstract of a scientific article to be just a summary. He declares that it is "a concise digest of the content of the paper" (p. 4). They argue that a summary is no more than a brief restatement of a text that was already read or studied. The Abstract, he explains, should "be self-explanatory without reference to the paper, but is not a substitute for the paper" (p. 4). In other words, reading the abstract should be enough to understand what the whole article contains.

Similarly, Borja (2014) states that the abstract simply "tells prospective readers what you did and what the important findings in your research were" (p. 13). He describes it -together with the title -as "the advertisement" of the article; i.e., they promote the idea and content of the work to the potential interested audience.

2.4.1.2.2. Features of the Abstract

From the above definitions of the Abstract, the first and most distinguished criteria are being explanatory, informative and attractive. Only a well-prepared abstract allows readers to recognise the key point of the article accurately. It also helps them know whether the article is or is not relevant to their interests. Then, they can decide to read the whole article or not ("American National Standards Institute", 1979. Cited in. Nair & Nair, 2014, p. 13).

Therefore, the Abstract is a very important component of the article because it is the first part to be read. If it is not well written and does not provide the required details, the whole work might be misdirected even if it is good and relevant. As McNab (1990) puts it, “I have the strong impression that scientific communication is being seriously hindered by poor quality abstracts written in jargon-ridden mumbo-jumbo” (Cited in Day, 1998, p. 29). That is to say, abstracts that are written in unclear, ambiguous and confusing words lead the articles to be uninteresting and useless. Hence, writers of scientific articles must “avoid using jargon, uncommon abbreviations and references” in abstracts. Jargon (technical words) can be difficult especially for non-native speakers of English (Borja, 2014, p. 14).

It can be said that the abstract acts like an announcement for the article. It “can persuade or put off readers” (Docherty & Smith, 1999, p. 1224). In addition, the abstract is the part of the paper which is available for reading in most electronic databases. For that reason, scientists and science writers must be careful when writing their abstracts if they want their articles to reach the intended audience. Therefore, they have to take into account the main features of a good abstract that are listed, in brief points, by Publication Manual of the American Psychological Association (APA, 2010). A finely crafted abstract must be: “accurate, self-contained, concise and specific, non-evaluative, coherent, and readable” (p. 2).

In order for the abstract to fulfil its purpose, it “should cover the aims of the report, what was found and what, if any, action is called for”. It does not have to be exhaustively detailed, “about 1/2 a page in length and avoid detail or discussion; just outline the main points” (Booth, Colomb, & Williams, 2003). In addition to what the abstract should contain, Labaree (2009) provides a list of what the abstract should NOT contain which is as follow:

- lengthy background information,
- references to other literature,
- elliptical (i.e., ending with ...) or incomplete sentences,

- abbreviations or terms that may be confusing to readers,

- any sort of illustration, figure, or table, or references to them. (p. 3)

2.4.2. The Introduction

After the Title and Abstract comes the Introduction. It is not easy to write it as well because many details are required.

2.4.2.1. Background

In addition to the fact that the Introduction of the article relates the whole work to the major theme it belongs to, it should explain the motive behind the conducted investigation and provide a glance on its major results. Steingraber (1985) concisely explains what the Introduction of a scientific article must contain in the following notes:

1. a description of the nature of the problem and current state of knowledge or understanding at the beginning of the investigation (background);

2. a statement of the purpose, scope, and general method of investigation in your study;

3. hypothesis/hypotheses and predictions. (p. 2014)

Then as well, Goben and Swan (1990) highlight the main components of the Introduction of an article. First of all, it should contain a description of the question or problem studied. Second, there must be an explanation of the reason behind studying this problem. Third, a description of the methodology used in the study is mentioned in a descriptive way. Finally, it has to briefly indicate the conclusion drawn from the study.

Not far from that, Wortman-Wunder and Kiefer (2012) describe the Introduction of a scientific article as a funnel introduction, i.e., starting from the general background of the study to the specific reason that led to the investigation of a particular problem. They mention that an introduction can be seen as “a telescoping focus, where you begin with the broader context and gradually narrow to the specific problem addressed by the report”.

It is important for readers to understand the main reason of the study -which is not only curiosity. Aiming to explain this reason, writers should present some related findings of previously conducted researches about the study in question. Day (1998) indicates that "the introduction summarises the relevant literature so that the reader will understand why you were interested in the question you asked" (p. 34). The purpose of this summary is to supply enough background data that allow readers to understand and evaluate the presented results without referring to previous publications on the subject. He adds that it "should also provide the rationale for the present study" (p. 40).

Similarly, Day and Gastel (2012) mention that the Introduction "should introduce the paper". That is to say, it is through the introduction, readers do not have to search or look for other works in order to understand the new work being presented in the article. However, this is not the only part of the introduction which interests readers; the problem in question is the key component which readers are actually looking for. Thus, "if the problem is not stated in a reasonable, understandable way, the reader will have no interest in your solution" (p. 5).

2.4.2.2. Features of the Introduction

The Introduction is not the first part, which is read in the article; still, it introduces it. It must be as attractive, explanatory and understandable as the abstract in order to have the readers convinced with the work. As Euripides says, "a bad beginning makes a bad ending" (Cited in Day, 1998, p. 33).

Accordingly, an introduction contains as obligation some essential details, which may require long space in the article. Yet, it should be kept "brief". Brief though writers have to ensure that "the reader knows enough to appreciate the relevance of the work" (Joshi, 2005, p. 132).

In order for writers to achieve the goal of the introduction, they can think of its components as answers to the following questions:

1. "What is the problem?" in which they state the question asked or the problem being investigated.
2. "Why is it important?" they explain the purpose of the study by presenting background literature about the topic.
3. "What solution (or step toward a solution) do you propose?" in which they demonstrate the methodology suggested to answer the question. (Tischler, 2014, p. 9)

Besides what was mentioned up to this point about the components of the Introduction, Doumont (2011) adds that it should "prepare readers for the structure of the paper". He summarises it into four constituents which are: "context, need, task, and object of the document".

To sum up the features of the Introduction of a scientific article, Brownell, Price and Steinman (2013) state that it is simply the announcement of the study that was conducted. It is expected to provide readers with enough information in order to appreciate the writers' specific objectives within a larger theoretical context. Thus, the topic must be clearly explained and specified.

2.4.3. The Methods and Materials Section

The scientific work is -in most cases- an experiment which aims at inventing something new, clarifying a discovery or explaining a phenomenon. Therefore, the scientific article which represents the scientific work to the world must demonstrate how this experiment was done. Under the heading *Methods and Materials*, scientists have to explain what was done, how and with what tools.

2.4.3.1. Background

The first and may be the most important reason that obliges scientists to explain the methodology of their work in their articles is to allow other -trained or expert- scientists to repeat the experiment. The purpose of repeating the experiment is to check the results. As it is mentioned earlier, a scientific experiment gives the same results if it is done by any other scientist. (Day, 1998; Docherty & Smith, 1999)

Alfred N. Whitehead, an English mathematician and philosopher, declares that "the greatest invention of the nineteenth century was the invention of the method of invention" (Cited in Day, 1998, p. 36). That is to say, describing how an experiment was carried out and how a discovery was found are crucial in science development, research description and their communication.

Not far from that, Carpenter et al. (2001) give more importance to the samples used in the experiment that is they should first be presented and defined and then explain the experiment itself. They state that this section "lists specimens used in the study and what methods or procedures were applied to them" (p. 771). This is crucial because the factor, which makes the biggest difference in any experiment, is the samples used.

According to Tischler (2014), the methodology should answer the following questions: first, "*How did you study the problem*?": the scientist mentions the type of the scientific procedure used. Second, "*What did you use*?": he lists and describes the materials used (animals, apparatus, solutions…). Third, "*How did you proceed*?": he explains the steps of the procedure in details (p. 11. [emphasis added]).

Therefore, the essential details that should be covered in the Methods and Materials section are listed as follow: (1) "*the experimental design*"; (2) "*the apparatus*"; (3) "*methods of gathering data*" and (4) "*type of control*" (Brownell, Price & Steinman, 2013, p. 4. [emphasis added]).

Similarly, Borja (2014) explains that "this section responds to the question of how the problem was studied". The description of the methodology enables other scientists not only to replicate the experiment and check the results but also start a new experiment on the basis of the methodology of an already carried one. For example, some scientists may think to provide different circumstances and check if they will have the same results.

2.4.3.2. Features of the Methods and Materials Section

The Methods and Materials section must provide enough details in order to "verify the findings and to enable replication of the study by an appropriately trained person". That is why it is "descriptive" (Jenkins, 1995, p. 289). The scientist must describe how exactly the results were found. In the world of science, many performers may have got similar ideas and observations; therefore, two -separate- scientists may happen to search in the same field and have the same ideas or results. The solution is, then, to explain in details the methodology because the differences between these two scientists and the works they have carried out will appear in the details. As Alley (1996) puts it, the solution is to "include description of the techniques used so someone could figure out what experiments were actually done" (p. 5).

It is important to note that in some scientific activities, not only one method or experiment is used. One experiment may have several stages and steps which require some space to be explained. Therefore, Johnson et al. (2007) insist that "each method should be described in a separate section" (p. 2829). For that reason, as a highlighted instruction for scientists is to "organise [their] presentation so reader will understand the logical flow of the experiment(s)". They suggest that "subheadings work well for this purpose" ("*Instructions for authors*", n.d.).

2.4.4. The Results Section

The *Results* section is the core part of the whole paper. It is where scientists present the findings of their investigation. The results are the real contribution of the scientists to their area of study.

2.4.4.1. Background

Publication Manual of the American Psychological Association (6th edition, 2010) states that the *Results* section "summarises the data collected and the statistical treatment of them" (p. 3). It is where readers check the findings gathered from the experiment which can take the form of numbers, figures and/or graphic displays in addition to text.

Wortman-Wunder and Kiefer (2012) highlight more detailed description of what is included in the Results section. They say that this section states: (1) "*the facts*" which represent the findings of the investigation; (2) "*detailed data*" about these facts in the form of "measurements, counts, percentages, patterns" which usually appear in tables, figures, and graphs; and (3) "the text" which explains the most important data and the relationships between the details.

Therefore, the nature of this section demands two types of presentation or two sorts of texts. The first type is narrative text (verbal text) which represents the description of data and the relationships among results. The second is the illustrative materials (non-verbal text) which display the data; they can be in the form of tables, figures, graphs, etc. (Brownell, Price & Steinman, 2013)

It is important to note that the Results section presents the findings but does not interpret or explain them. Day (1998) insists on scientists that they "DO NOT discuss the results or speculate as to why something happened" (p. 41. [original emphasis]) because this is going to be in the next section; Discussion.

2.4.4.2. Features of the Results Section

Wortman-Wunder and Kiefer (2012) have provided three "rules of thumb" which should be taken into account by writers when it comes to the Results section. These rules are as follows:

- present results clearly and logically
- avoid excess verbiage
- consider providing a one-sentence summary at the beginning of each paragraph if you think it will help your reader understand your data.

Basically, in the Results section, there are only results. Joshi (2005) claims that the findings should be presented as they are found and collected; "raw data include all observations" (p. 132), neither interpretations nor implications should be mentioned or embedded. Raw information must be clearly presented; that is to say, only what was gathered from the experiment(s) and based on the methodology, and arranged in a logical and/or chronological order.

In the same vein, Tischler (2014) advises writers to make their findings "digested and condensed, with important trends extracted and described". The results are the new knowledge contributed to science and the world; therefore, it is required from every researcher to deliver them as "clearly and simply" as possible (p. 12).

Johnson et al. (2007), earlier, declare that the discussion and/or interpretation should be separated from the Results section. The readers expect to find the data gathered from the experiment and only these data. However, there are some investigations which require more than one experiment or there might be several stages for one experiment. Each of these experiments or stages may have its own results, and the next step requires the declaration of these results. In this case, the simple description of data at the level of the Results section does not help writers. In such a situation, writers can use "brief statements" to describe the findings of each stage or experiment. Though, they should be kept in the same (generally chronological) order as the methods used to obtain them were presented in the previous section (Materials and Methods). This way allows both researchers to present their data appropriately, and their audience to keep up with the flow of results of the work (Blackwell & Martin, 2011).

2.4.5. The Discussion Section

As mentioned above, the results are presented without interpretation in the Results section. They are though interpreted in the Discussion section. This part answers the question: *What do the data presented in the previous section mean*? In this stage, the scientist discusses each of the findings presented earlier and extracts the general conclusion from the entire investigation.

2.4.5.1. Background

This discussion should be related to the main idea. The scientists must keep in mind the original question or hypothesis they are investigating. They must interpret the results in relation to their main context. Therefore, the Discussion should shed light on: first, "the relationship between the results and the original hypothesis". It is at this stage where the scientists explain whether their results support the hypothesis or exclude it. In some cases, the final result causes the hypotheses to be modified. Second, it presents "an integration of results with those of previous studies". The scientists express their contribution and what they have added to what was already done. This enables the audience to understand the observation which led to the whole investigation from the beginning. Third, there might be also some explanations for "unexpected" results and observations. These unpredicted results can be investigated later in a new work (Steingraber, 1985). In other words, it is imperative for scientists to report and explain all the findings, whether significant or insignificant, for the credibility of their work.

Similarly, Day (1998) states that the Discussion should "highlight the most significant results". He further indicates that this stage is not merely a restatement of the results. However, it is an explanation of conclusions and interpretations drawn from the results. The Discussion should clearly answer these two questions: "How did your results compare with the expected results?" and "What further predictions can be gleaned from the results?" (p. 42).

Correspondingly, Blackwell and Martin (2011) explain that the Discussion part should state the meaning of the results and their relation with what was previously reported in addition to the implications that can be drawn from them. Besides, in many -if not all- cases of scientific investigations, problems -concerning the procedure, the materials or even the results- may occur. Therefore, scientists can suggest improvements to avoid such problems in further work or to enhance the one in question. These problems and their -suggested- modifications or expansions are included in the Discussion.

This section relates all the previous -chief- sections: Literature Review, Methodology and Results. That is to say, the Discussion interprets the findings in light of what was previously shown about the subject of the study -the *Literature Review*- and explains the new understanding of the problem -the *Methodology*- taking the *Results* into account ("*Instructions for authors*", n.d.).

2.4.5.2. Features of the Discussion Section

The Discussion is not easy to be written. The difficulty lies in the fact that the discussion is an explanation and interpretation of the results. Writers should be careful not to restate or repeat them. The results of the investigation are considered the new contribution to science; that is why it is necessary to explain them correctly, clearly and objectively. Misinterpretation causes confusion which may lead to the rejection of the whole work or to its misplacement.

According to Day (1998), the Discussion needs to be detailed in which the "principles, relationships, and generalizations" revealed by the results are covered. The interpretation should clearly show how results "agree (or contrast)" with previously reported work about the same subject. In addition to that, in experiments, there might be some unexpected results or reactions; that is why scientists must be objective and honest, and point out these unexpected findings. Besides, in the Discussion section, researchers can show the implications and the applications of their work suggesting or recommending further investigations or modification to the original one (p. 31).

Not far from that, Docherty and Smith (1999) show that the *Discussion* "should emphasise the new and important aspects of the study and the conclusions that follow from them" (p. 1225) and which did not appear in the Introduction or Results sections. Therefore, it must show objectively and truly the decision of the scientist if the hypothesis is confirmed and supported, rejected, or if it is not possible to make a final decision about it with confidence (Joshi, 2005).

To sum up the features of the Discussion section, it can be said that it interprets the data with regard to the objective, hypothesis and observations. It is not a repetition of findings but it must accurately detail sudden results which occur during the experiment (Brownell, Price & Steinman, 2013). Even though these key points make it appear to be easy to write, it is the hardest section to "get right" (Borja, 2014). This is because it is considered (along with the Results section) the most important part of the article.

2.4.6. Additional Sections

In addition to the Title, Abstract and the IMRaD sections, the article still needs other units to be complete. These parts are necessary to: Close and end the paper in the

Conclusion; provide details about the previously published works cited in the paper in the *References*; and present extra information that could not be in the above sections in the *Appendices*.

2.4.6.1. The Conclusion

The scientific article is an academic paper, which follows the structure of *introduction -body- conclusion*. As noticed in several articles or according to what some journals choose, the *Conclusion* is attached to the *Discussion* section and considered the same. However, the article still needs a conclusion. It has different features and states other details that are not mentioned in the sections that come before.

2.4.6.1.1. Background

The Conclusion focuses on what is found and what it means in a more general way that relates the whole work to its broad context. It is not necessary to be as long as the other sections, few sentences presenting the fruit of the work are enough. It is better to avoid making it long -just to impress- which may lead to awkward repetitions.

As Carpenter et al. (2001) put it, “the Conclusion is a good place to set your results in a bigger picture”. That is how the readers understand the overall meaning of the article and the significance of the whole investigation. Some readers look for the *so what* in the conclusion to have a better understanding of the entire work (p. 780).

Correspondently, the conclusion answers the question: “So what?” in order to first, place the entire study in its -broader- context; and second, explain the contribution that it provides to science (Bunton, 2005; Johnson et al., 2007; Doumont, 2011).

Hengl and Gould (2002) list the main functions of the Conclusion which can be summarised as follows: first, “answers research questions,” here comes the connection between all the sections together from the literature review posted in the Introduction, to the findings stated in the *Results* and their meaning in the *Discussion*, passing by the way of investigation mentioned in the *Methodology*. Second, it "explains discrepancies and unexpected findings" which are important to be mentioned in the *Discussion* and explained in the Conclusion. Third, it "states the importance of discoveries and future implications" that allow the reader to know the position and significance of the whole work (p. 9).

In short, the *Conclusion* is where readers should find whether the hypothesis was proved -or not- or whether the question was answered, what results support that and the recommendations that can start from other work.

2.4.6.1.2. Features of the Conclusion

According to Hengl and Gould (2002), the *Conclusion* "allows scientific speculations". It is recommended to mention the unexpected results which might be occurred during the investigation in the Conclusion section. They must not be hided for they can be the most important ones. They have suggested to avoid using expressions like: "*It may be concluded...*" because they indicate uncertainty (p. 4).

It is also important to note that the *Conclusion* does not contain new information. Bunton (2005) says that the Conclusion "offers a new insight on the study and -might- open the road for extra work based on the findings (modification) on the same idea being discussed" (p. 220). This is due to the fact that most -if not all- scientific researches and experiments lead to future perspectives which are one (or more) idea of what can or must still be done in the light of the original idea and its results. However, it should be clear from the beginning to those who decide to consider such future perspectives. It is then recommended that, in the conclusion of the article, scientists have to show their intention to do this extra work on the experiment by themselves making use of expressions like "*In the coming months, we will…*". If not so, they can express it in the form of an invitation to other scientists starting it like this: "*One remaining question is...*". (Labaree, 2009, p. 39. [emphasis added])

Furthermore, Brownell, Price and Steinman (2013) state that the *Conclusion* together with the *Introduction* sections provide the readers with enough details that allow them to get an overall idea of what has been investigated and discovered in this study. However, the specific details of how the research was carried out would not be known unless they check the other sections.

2.4.6.2. References or Literature Cited

References is the last section in the article. It is an essential part of any scientific and academic paper. It is where writers mention all the sources of literature they have referred to in their article.

2.4.6.2.1. Background

There are several styles used to cite these sources (MLA, APA, CBE); though the choice depends on the requirements of the journal in most cases. In addition, this section may have a different heading depending also on the demand of the journal. It can be: 'References', 'Literature Cited', 'References Cited' or 'Bibliography'. These titles might seem similar; however, there is a slight difference between them. In effect, *References* are the sources actually used whether they are books, articles or reports; i.e., the researcher relied on them and might have refer to parts of them in her/his paper. A *Bibliography*, however, contains references that might be read but not specifically used and cited in the text in hand; usually provided for extra reading. Bibliography is rather found in books and other literary writing but not in scientific articles. *Literature Cited* is the heading used which indicates that the following list of references were used and referred to in the text. It tells what the section is actually about and it is the choice of most scientific journals. (Huth et al., 1994; Day, 1998; Hengl & Gould, 2002)

In the scientific work particularly, references are very important and citing them correctly is crucial. Scientists rely on works in the same field of their interest. Thus, if these works are not cited appropriately, they can be “seriously misleading” (De Lacey et al., 1985, p. 884). A mistake in the title, similar names confusion, wrong date, etc. should be considered and avoided.

As stated by McMillan (1988), the references are listed by authors’ names. The “footnotes” are used in literature papers. In scientific papers, however, in-text citations are rather preferred. She uses “Literature Cited” as the title of this section.

Correspondingly, Huth et al. (1994) explain that the sources follow an alphabetical listing in the *Literature Cited* section starting each one by -first- author’s last name. The references that are cited are those which were actually used in the body of the paper.

2.4.6.2.2. Features of the References Section

Apart from the details that should be taken into consideration by authors, the References section is another part where writers might fall in the trick of *impressing*. It is a common mistake to think that the more references they cite, the more their work looks better. This is not true; they have to cite only what is necessary and the number of references, sometimes, depends on the subject investigated in the paper. Halsy (1998) indicates -in this issue- that “it is rarely necessary to have more than 40 references in the longest paper” (p. 110).

Thus, scientists must bear in mind that this section provides the readers with the list of all key resources that the authors “drew upon” to design their study in order to sustain or motivate their discussion. (Hengl & Gould, 2002; Johnson et al., 2007). In view of that, the authors must be careful about the references they have used because it is their “responsibility” to make sure that all of them are cited in complete form and correct position (Hoogenboom & Manske, 2012).

The nature of the content, *science*, -here again- restricts the type of sources that can be referred to in scientific articles. As discussed earlier, science is exact and accurate and deals only with facts. Therefore, not any source can be used. Brownell, Price and Steinman (2013) notice that in scientific papers "most references will be to the primary literature (i.e., journal articles) and, to a lesser extent, books". Previously achieved results and facts are generally published in the form of scientific articles (and not-so-often books) which makes them gain credibility and trustworthiness. However, "popular literature and the Internet should be used sparingly and with caution" and should not be overused (p. 7).

It is important to note that references must be clearly and exactly presented. Authors' last name, year, title and publishing details must be included (Carpenter et al., 2001; Hengl & Gould, 2002; Johnson et al., 2007).

2.4.6.3. Figures and Tables

Figures and Tables do not constitute a separate section by themselves, they make part of the *Results* section with which data can be presented (as mentioned above). Sometimes, they can also illustrate some parts in the *Discussion* section. These illustrations have a great importance in explaining, clarifying and exemplifying the data provided in the paper.

2.4.6.3.1. Background

Many scientific articles contain *Figures and Tables*. For that reason, authors of scientific articles should know how to employ them to present their findings. Strunk and White (1987) insist NOT to use tables or graphs just to be "fancy". If the information can be summarised in a few sentences, then it is not necessary to use a figure or table. Instead, figures and tables should be used when they are more efficient than the text (McMillan, 1988).

Tables and Figures are better than narrative text in expressing the exact numbers and values of data. They are also more effective in presenting the "specific inter-relationships" between the different variables and results. A visual illustration is used as proof to consolidate the findings and show their validity (Byrne, 1998). Similarly, Lester and Lester (2015) state that visuals and graphic displays enable the scientists "to analyse trends and relationships in numerical data". In order not to confuse readers, each of these visuals should present only one type of information as simply and briefly as possible.

In addition to that, Tables in particular are able to summarise a large amount of information that a piece of text may take a large space; a text containing a lot of data might be ambiguous and, thus, misinterpreted by readers. Besides, the details presented in *Tables* should not be repeated in a text format. It is the writers' responsibility to choose one format over the other when necessary and make sure that not one of them is a repetition of the other (Carpenter et al., 2001). The key concept to be considered is that, on the one hand, each of them needs the other, i.e., the text needs tables/figures to summarise big quantity of data; on the other hand, the tables and figures need the text to be explained and put into and relate to the overall context of the work (Maloy, 2001).

In effect, text can be used along with *Tables and Figures* through what is known as *legends* or *captions*. Each table or figure requires a brief description of its contents. The positions of the captions depend on the illustration used. Tables are presented and read vertically, i.e., from top to bottom; therefore, its caption should be placed above it. In contrast, different types of figures and graphs are usually observed from bottom to top, that is why their captions are better placed below them. Both illustrations need a short title including their main indicated points whether contained within the captions or separated from them (Lewiston, 2011).

It is crucial to point that since the Tables and/or Figures indicate new pieces of information and are not simple repetitions, they must be referred to in the main text of the section to where they belong, either *Methodology*, *Results* or *Discussion*. This in-text indication, in addition to the caption, should in few words present the important result or explanation that are drawn from the figure or table (Johnson et al., 2007).

Brownell, Price and Steinman (2013) also explain that *Tables and Figures* are used to supply the text and present the data in an easily understandable form. However, whenever they are used, they must be accompanied by narrative text. Yet, this piece of text should not repeat the data presented in Tables and Figures.

Hoogenboom and Manske (2012), in contrast, state that tables should be clear enough so that they can stand alone and be totally understood. They should be independent from the text so that readers do not have to examine the whole paper.

All in all, *Tables and Figures* should be presented in the paper with the necessary amount of information to make them clear and effective. In order to do so, these visuals should be introduced (mentioned in the text); shown (presented) and discussed (in the caption) (Lester and Lester, 2015).

2.4.6.3.2. Features of Figures and Tables

Figures and Tables are "independent units" that are used to support text in which a large quantity of data is presented in the form of numbers and/or symbols. However, they must be supplemented by explanatory captions so that they can be fully understood by readers especially those who do not read the entire paper. Nevertheless, visuals cannot substitute a -verbal- summary of the results, they can only support them (McMillan, 1988).

Thus, *Tables and Figures* are used to organise information with the purpose of making them "easily evaluated by the reader" (Maloy, 2001, p. 6). However, they should not present large amounts of "raw data" so as not to cause confusion. In addition, Tables and Figures can be put in the section they illustrate (Results or Discussion) as they can be separated and put in the Appendices at the end of the paper (Maloy, 2001).

The following points summarise the main features that should be considered when using Tables and/or Figures:

1. They must be ordered and numbered (Table 1, Table 2) to be easily referred to in the article.

2. If they are integrated, there should be no page break in the middle of a table or a figure.

3. The text should not be around them; it should rather be above and below. They should "stand out on the page, not be buried in text".

4. They must not repeat already presented data.

5. Images and graphs must be clear, large enough and include -if necessary- suitable scale bars. (Maloy, 2001; Johnson et al., 2007; Lewiston, 2011)

Conclusion

The scientific article is the most known paper in the communication of science and has a distinct format, which makes it a special type of academic papers. This chapter presented the chief aspects that characterise scientific articles in order to highlight their role, importance and usefulness. The layout of the scientific article -as it is known today- has the lion's share among the reasons that led to this gained position. The IMRaD (*Introduction*, *Methodology*, *Results* and *Discussion*) format is considered a pattern more than being a simple layout since it benefits both writers and readers.

The scientific article communicates science and science needs clarification. The standard layout alone is not enough, the language is also as important. Therefore, the next chapter highlights the language aspects that should be considered by writers of scientific articles.

Chapter Three

Syntactic and Lexical Features of the Scientific Article

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Syntactic and Lexical Features of the Scientific Article

Introduction

In communicating science, every detail counts. The focus should not be only on conveying the intended message correctly and through an accepted organisation, it should also give similar importance to the aspects of the language; i.e., English, such as choice of appropriate words, grammatically correct sentences and cohesion.

After discussing the layout of scientific articles and stating why one standard format is important for both writers and readers, this chapter goes beyond the format and studies the features of the writing style of the scientific article. It highlights the key language points that are specifically used and frequently occur in scientific articles as the syntactic and lexical features which give the scientific article its specific nature. This chapter also addresses the particular use of some expressions and structures in each of the article sections starting from specific type of vocabulary to distinctive occurrence of tenses.

Additionally, it states some of the common linguistic problems that scientific writers are confronted with when writing their articles. These problems, such as inappropriate choice of words, excessive use of jargon as well as passive voice, subject-verb disagreement and unfitting phrasal verbs, are due generally to the writers' intention to sound scientific, to their lack of knowledge about these aspects or possibly to their wrongly acquired ideas about writing in science.

3.1. The Importance of Language and Style in Science Communication

The writing style often refers to "the manner of expressing thought in language characteristic of an individual, period, school, or nation" (Webster, 1969, p. 368). The writing style may also refer to "linguistic aspects that identify a particular writer"

(Aquilina, 2014, p. 6). That is why the writing style is seen as an individual effort of writers to make their prose unique and/or different from others' writings; or as known as '*the writer's touch*'. However, the writing style -beyond the basics of spelling, grammar and punctuation- is "the choice of words, sentence structure, and paragraph structure, used to convey the meaning effectively" (Sebranek, Kemper & Meyer, 2006, p. 111). In this case, the writer's own identity does not make part of the style. For example, the scientific style is impersonal in its nature and so it demands a clear writing style that expresses the intended meaning without the writer's touch or presence.

These essential elements of grammar and spelling are referred to as "*rules, elements, essentials, mechanics,* or *handbook*" which are required in any piece of text; on the other hand, the choice of words and sentence and paragraph structures are referred to as "*style,* or *rhetoric*" (Crews, 1977, p. 129). According to Strunk and White (1979), these rules are about "*what* a writer does"; however, style is about "*how* the writer does it". Following the rules gives writers great flexibility to express their thoughts and ideas. Style controls the flow and connection of these ideas. The characteristics of a good writing style then are to:

- express the message to the reader simply, clearly, and convincingly;
- keep the reader attentive, engaged, and interested. (p. 66)

The writing style is important in sharing science. Clarity and conciseness are required to share scientific facts and findings. However, a good writing style does not cover a bad scientific work. As Plaxco (2010) puts it, scientists must bear in mind that "even the most skilful writing cannot turn bad science into good science"; instead, a "clear and compelling writing makes good science more impactful, and thus more valuable" (p. 2261). Thus, acquiring the background knowledge in vocabulary and grammar is not enough in communicating science because "the finer points of style and presentation will often make all the difference between a good and a mediocre publication" (Foster, 2008, p. 63). For that reason, writing well in science "requires as much care and thought as the experiments or research being communicated" (Lutz & Storms, 1998).

Therefore, in the scientific communication, "language is the starting and the ending point of science" (Aaronson, 1977, p. 5). Style is about how phenomena and concepts are delivered or conveyed through language. It is then of great importance in such communication. As stated by Lavoisier (1789), language cannot be separated from science nor can science be delivered without language. He highlights the role of language in science saying that:

> It is impossible to dissociate language from science or science from language, because every natural science always involves three things: the sequence of phenomena on which the science is based; the abstract concepts which call these phenomena to mind; and the words in which the concepts are expressed. To call forth a concept a word is needed; to portray a phenomenon, a concept is needed. All three mirror one and the same reality.
> (Cited in Aaronson, 1977, p. 5)

3.1.1. The Scientific Writing Style

Defining the word style in the scientific context is not as easy as in the literary context. Style is known to be the writer's own way of expressing ideas and explaining concepts; however, it is proved so far that communicating science needs to be impersonal and independent from the writer. Style can be defined as the use of "proper words in proper places" which means it is a 'transparent' style (Swift, 1720. Cited in Aaronson, 1977, p. 6). In other words, readers should be able to see through the text to the intended meaning without a need for decoding or translating the language into an easier or clearer one.

As stated earlier, the scientific writing is one type of academic writing. Therefore, almost “every element of style that is accepted and encouraged in general academic writing is also considered good practice in scientific writing” (Alley, 1996, p. 10). The characteristics of academic writing include “a formal tone, use of the third-person rather than first-person perspective (usually), a clear focus on the research problem under investigation, and precise word choice” (Hartley, 2008, pp.3-4). In effect, what makes science writing different and special is the focus and the relative importance that are put on some particular elements of style. The truth is there is not a set of particular syntactic rules that are specifically found and used in scientific writing only. It is a matter of occurrence (some points and features are more frequent than others) and/or preferences.

In science, ideas are based upon “precise mathematical models, specific empirical (primary) data sets, or some combination of the two” (Council of Biology Editors, 1994, p. 753). Therefore, scientists must use precise language to communicate and explain their ideas. Long prose and extended explanations are not quite accepted in scientific texts and in scientific articles in particular. That is why the scientific writing must be brief, clear and precise. (Aaronson, 1977)

Furthermore, science students and researchers concerned with writing reports and articles must consider that scientific writing has two main characteristics: *Formal* and *impersonal*. In other words, in almost all types of scientific activity, the scientists are not involved as participants in the activity and thus, they should not express their feelings, attitudes or personal opinion as well as their subjective comments that are not required.

In the scientific writing style “figurative language” is also to be avoided because it tends to create ambiguity, vagueness and inaccuracy. Figurative language is usually used in order to employ casual reading which is by definition *imprecise*; that is what the scientific writing avoids. For example, a sentence like “*the rat was as white as snow*” is not likely to be used in the scientific prose. It is preferable to say "*the rat was white*/*the white rat*..." in case the colour of the rat makes a difference in the experiment. Comparison and contrast are frequently used in science; however, simile is a different type of comparison that is rather used in literary texts. In addition to excluding simile in EST texts, it never makes use of rhetorical elements such as *metaphor*, *personification* or *hyperbole* (which are rather used in literature). The main reason behind excluding the use of similes, metaphors and any other type of figurative language is the fact that it is difficult for readers to objectively evaluate the research findings if they are left to imagination (Day & Gastel, 2012; Li & Li, 2015).

3.1.2. The Importance of Style to Science Writers

The writing style is "how the writer presents the words to the reader" (Humpage, 2013). It is imperative in science communication for writers to know that a good idea in science might be killed by a poor language style. In effect, "ideas will have little impact, no matter how well the research, if they are not communicated well" (Lewiston, 2011). Therefore, learning, understanding and using the elements of style are crucial skills which scientists and science students should learn. Besides, it is important to notice that scientists or science students must acquire a good command of English and sufficient awareness of EST.

It is important to note that writers should know and understand that it is not always good to sound scientific. Scientific writing is not the appropriate place to flex muscles or to show off for this can widely appear in literary texts such as poems. Using jargon and technical words -excessively or inappropriately- will not help readers understand what is exactly communicated. According to Doumont (2011), "effective writing is readable"; i.e., readers can "understand them effortlessly, unambiguously, and rapidly". Writers should realise that "there is no need to write about science in unusual, complicated, or overly formal ways in an effort to ‘sound scientific’ or to impress your audience” (Doumont, 2011).

However, writing itself is not an easy task; writers should be aware that there is no single, correct way to write. In other words, writing style is not a rule that they can apply. As a matter of fact, there are plenty of ways to write and to solve the problem of style in science. The solution is not to follow how others write or “copy someone else’s voice” (Plaxco, 2010, p. 2262), the best way is to recognise what works for the writer and what does not work in relation to their area of interest or subject. The scientific writing style “requires special attention to order and organization” (Plaxco, 2010, p. 2262) because scientific papers, such as dissertations, manuscripts and articles, are “divided into sections” and writers must know what type of information goes into each one as well as the appropriate language and/or voice that are suitable for this type of information (Lewiston, 2011). That is why knowing how to write is significant for writers willing to participate in the global record of science. According to Ebel, Bliefert and Russey (1987), “only the researcher who is competent in the art of written communication can play an active and effective role in contributing to science” (p. 5).

Moreover, it is recommended for science writers to acquire a sufficient amount of vocabulary specific to their particular field of study. However, learning essential vocabulary is not enough for writers; knowing how words go together is as necessary in science communication.

For science writers who are non-native speakers (hereafter NNS) of English, it is difficult to learn the characteristics of style as clarity, economy and objectivity in addition to the necessary rhetorical devices, separately from general English features which include all sorts of formal as well as informal styles. However, it should be noted that “non-native speakers of English can write effective manuscripts, despite errors of grammar, syntax, and usage, if the manuscripts are clear, simple, logical, and concise" (Drubin & Kellogg, 2012, p. 1399). Therefore, NNS science writers must understand that their ability to "participate in the international scientific enterprise is directly related to their ability to produce manuscripts in English that are "clear, simple, logical, and concise" (Drubin & Kellogg, 2012, p. 1399). This should be put into consideration by experts of scientific journals as well.

3.1.3. The Importance of Style to Science Readers

Considering readers of science is of paramount importance in the choice of style and language used in communicating science. Accordingly, there should be a "focus on reader engagement and readability" because "if scientists find it hard to read papers, people from the non-research world who want to read about our science will find it even harder" (Doubleday, 2017).

Most science writers think that only professional scientists as experts of journals read their papers. For that reason, they drop some explanations or basic definitions ignoring the fact that many readers are considered strangers to their field of research (Doumont, 2011). In fact, science readers are "science communicators, journalists, entrepreneurs, policymakers and interested members of the general public are all motivated to follow the latest scientific research" because this is the 'knowledge age' and almost everyone is interested in science. (Doubleday, 2017)

Moreover, writers in science must put in mind that science is already difficult, and for that the language used in communicating science must not increase its difficulty; it rather should make science clear. A good and coherent writing is expected to help readers understand the logic of the writers and the flow of ideas they present as they present them. The goal of good writing is mainly to make the "reader's job as easy as possible" (Plaxco, 2010, p. 2261) where scientific prose must present the ideas and findings without ambiguity; the text should have only one interpretation.

3.2. Lexical Features

3.2.1. The Importance of Vocabulary in Scientific Style

Vocabulary can be defined as “the words we must know to communicate effectively” (Neuman & Dwyer, 2009, p. 385). Still, what is meant by vocabulary -and how learners of a foreign language should see it- is not individual words only, but it includes orthography, pronunciation, context and conjugation. These elements are in the core of the process of learning a new language (Nation, 1990). This definition exceeds also to more than just a single word.

According to Lewis (1993), vocabulary is the words of a language, including single items and phrases or groups of several words which convey a particular meaning, the way individual words do. Vocabulary learning is “a continual process of encountering new words in meaningful and comprehensible contexts” (Harmon et al., 2009, p. 58).

There are several ways of learning vocabulary; one of them is using the language. As Nation (2001) describes it, the relationship between vocabulary knowledge and language use is “complementary”. In other words, knowledge of vocabulary enables language use to a certain extent and, conversely, language use increases vocabulary knowledge. Although, NNS students, who need English for specific -and urgent- purposes (like the case study in this work), do not have the time to learn vocabulary in a slow pace and go through the different techniques and stages of learning English; it is still crucial to learn and use vocabulary. The fact that vocabulary is a major component of literacy, learning and knowledge cannot be denied at any stage or in any case.

As stated by Cohen (2012), vocabulary refers to the words employed by a language in a particular field of study. Understanding and using new concepts represented by words is important for students who are confronted with "a great deal of new terminology in the passages they read, especially in content areas such as science" because science is "a discipline that relies heavily on students' ability to understand new terms and concepts" (p. 72). Therefore, science students are recommended to focus on vocabulary since it helps them both understand required texts and communicate their own thoughts and findings using correct words and terminology.

In the same vein, vocabulary is that aspect of language which continues to develop and evolve for as long as one has contact with the language. Vocabulary plays a chief role in learning any language as well as in communicating any field. Many researches indicate that a rich vocabulary is a critical element of the reading ability as well as the writing skill. First, comprehension improves when almost all the words are clear. The reader must have a vocabulary set rich enough to support the understanding of the text. Second, words are the currency of communication where a strong vocabulary improves all areas of communication including writing (Hirsch, 2003; Stahl, 2005). In addition to that, when learners improve their vocabulary, their academic and social confidences improve, too. Students' knowledge of words impacts their achievement in all areas of the curriculum since "wide vocabulary and broad knowledge go together" (Hirsch, 2003, p. 10) and "knowledge *is* vocabulary knowledge". (Stahl, 2005, p. 29)

In short, learners of foreign languages need to learn and enlarge their vocabulary. According to Wilkins (1976), "control of vocabulary and of grammatical structure go hand-in-hand, the attention of methodologists was first directed to vocabulary" (p. 3). Consequently, in learning to communicate -whether in written or oral form- vocabulary has the priority. There is not much value in being able to produce grammatical sentences if one has not got the vocabulary that is needed to convey what one wishes to say. In effect, "without grammar, very little can be conveyed; without vocabulary nothing can be conveyed" (Wilkins, 1976, p. 97). For instance, NNS users of English may manage to communicate using individual words and express their thoughts without necessarily having acquired grammar (Thornbury, 2002). As Krashen puts it, "when students travel, they don't carry grammar books, they carry dictionaries" (Cited in Lewis, 1993, p. 25). However, when it comes to academic and scientific writing, vocabulary alone is not sufficient.

Coming to the point, vocabulary knowledge is a critical tool for foreign language users because a limited vocabulary in a language impedes successful communication in any field of study or work no matter how these learners are qualified in this field. Schmitt (2000) underscoring the importance of vocabulary acquisition, says that "lexical knowledge is central to communicative competence" (p. 55) because lexis is "the core or heart of language". (Lewis, 1993, p. 89)

Taking into consideration the fact that science students are expected to improve their reading and writing capacities, vocabulary is a good start and it is recommended for them to work on their vocabulary knowledge including spelling, understanding and the ability to correctly use the words in their contexts. Nation (1994) mentions that vocabulary is "not an end in itself". In other words, improving vocabulary has a direct, significant and positive influence on the ability to increase language proficiency. Therefore, a rich vocabulary knowledge facilitates the skills of listening, speaking, reading, and writing. All in all, instead of separating vocabulary from the other language points, it is more useful to consider it as a "solid bedrock" upon which the whole language proficiency is built. (Meara, 2002)

In EST discourse, vocabulary has the same role and importance. Basturkmen (2014) explains that "identifying and teaching the grammatical structures and vocabulary seen as of central importance in scientific and technical writing" (p. 35). However, it must be noted that even if scientific and technical writing has the same grammar as General English, particular grammatical structures and vocabulary items are used more frequently.

3.2.2. Vocabulary in EST Discourse: Nature and Types

In any type of text or register, four types of vocabulary are distinguished depending on frequency and function. They are ordered as follows: “high frequency words; academic vocabulary; technical vocabulary; and low frequency words” (Chung & Nation, 2003, p. 103). The most frequent and used ‘2,000 words’ of English are *the high frequency words* which contain almost all the grammatical words of English (such as articles, prepositions, etc.) in addition to content words as well (such as *say*, *people*, *come*, and others found in the list of most frequent words in English made by *The Corpus of Contemporary American English*; COCA). A specialised expansion of the first type is “academic vocabulary” or “sub-technical vocabulary”. This category does neither belong to high frequency vocabulary, nor to technical words; though, it can be seen more related to the former than to the latter (such as strategy, stage, accustomed, etc.). A technical word usually has a singular specialised meaning. The last category of vocabulary consists of the rest of English words and considered the low frequent words such as proper names. (Nation, 2001; Chung & Nation, 2003)

However, it is not easy to draw the line between these categories because “one person’s technical vocabulary is another person’s low frequency word” (Nation, 2001, p. 3). Indeed, a word can be considered low frequent in a context, subject or register and in the same time it is high frequent in another context. For instance, different contexts would use the same word with completely different meanings such as “curious, wing, to arm, gate, approximately”. (Nation, 2001, p. 5)

Science possesses its particular jargon (specialised vocabulary) composed of technical words and of “semi-technical words” which are ordinary in nature and technical in use. According to Li and Li (2015), words in science fall into four categories regarding their “formation, meaning and use”. The first category is “pure ST words” (ST refers to scientific); examples are “hydroxide, diode, promethazine, isotope, etc.” These words are typically composed of “Latin or Greek morphemes” and have only one sense which is used in a singular field. The second type is *semi-ST words* as “frequency, density, energy, magnetism, etc.” They also have a single meaning but it is usually found in different fields or professions. The third one is *common ST words* such as “feed, service, ceiling, power, operation, work, etc.” These are similar somehow to semi-technical words shown above. They are specialised words which have different meanings depending on the field they are used in. In other words, they depend on context to be explained or understood. A good example is the word *feed* with the basic meaning of to give food to a person or an animal can be used in different fields with different meanings such as: “To supply water, to provide electricity, to deliver, to load, cutting feed, power source, etc.” This category of words is “freely collocated with other words and are most widely and frequently used in fields of various professions” (Li & Li, 2015, p. 161). The fourth category is *built ST words* like “microbicide, waterleaf, medicare, CSMA, etc.” They are called *built* because they are formed through different ways of word forming using “affixation, compounding, blending, acronyms, etc.” These words are more frequent in EST than in general English because they contribute in making the scientific text clear, concise and precise. (Li & Li, 2015, p. 162)

Similarly, Menon and Mukundan (2010) consider that the most remarkable categorisations of words in scientific texts are those suggested by Cowan (1974) and Nation (2001). Both scholars have similar categories or “degrees of technicalness”. This categorisation is detailed as follows:

1. Highly technical words: have a singular meaning and rarely appear outside their particular field such as *atom*, *molecule*, etc. in chemistry.

2. Sub-technical words: are ‘context independent’ words (Cowan, 1974, p. 391) which are frequent across similar disciplines but the majority of their uses has a specialised meaning related to the particular field in which it is used. This specialised meaning they have in this field is usually understood outside the field, such as the word *memory* in the computing field (Nation, 2001, p. 199).

3. Semi-technical words: have one or more general English language meanings and in technical contexts they take on extended meanings.

4. Non-technical words: are words which are common and have only ONE -general rather than specialised- meaning, for example ‘hospital’ and ‘judge’.

Trimble (1985), however, provides a different classification of vocabulary in EST discourse. First, he uses the term *lexis* which means “all the words and phrases of a particular language” (OEF, 2011, p. 739). Instead of four categories, Trimble (1985) has divided lexis in EST discourse into three categories: “1. technical vocabulary, 2. sub-technical vocabulary and 3. Nominal compounds”, also known as noun strings (p. 128). These three categories are detailed below.

3.2.2.1. Technical Vocabulary

Technical vocabulary refers to “highly specialised lexis in the subject-matter courses” (Trimble, 1985, p. 128). It is also called *jargon* by some other scholars or dictionaries (Nash, 1993; Sonneveld & Loenning, 1994; Lundin, 2013; Peterlicean, 2015). The term *terminology* is also used to refer to the same type of vocabulary which the Oxford Dictionary (2011) defines as “special words and expressions used in a particular subject” (p. 458). For the term *technical*, it describes it as “of a particular subject” giving the following example as an explanation: “the *technical* term of physics” (e.g., molecular, inorganic, electron, etc.). (p. 455)

Similarly, Chung and Nation (2003) state that “technical vocabulary is subject related, occurs in a specialist domain, and is part of a system of subject knowledge” (p. 107). That is what made technical vocabulary of a major concern for learners who have special purposes in language learning such as scientists who need English to communicate their work or their findings.

More precisely, Ragini (2012) mentions that “Technical Vocabulary is the specialised vocabulary of any field which evolves due to the need for experts in a field to communicate with clarity, precision, relevance and brevity”. In other words, technical words emerge as a response to the requirements of specialists in a certain domain (e.g., science) to communicate significant and specific ideas or concepts briefly and concisely. For instance, the need to avoid repeating the expression “*an antibody with a catalytic activity*”, the word *Abzyme* is a technical term which emerged from joining two words: ***antibody*** and ***enzyme*** (acts as biological catalyst). (Lee & Benkovic, 1998, p. 438)

Each subject -such as science- makes use of words which are either specific in that subject area (not in general English), or common but used with special meaning in that subject area. These words are called technical vocabulary or subject-specific vocabulary which indicates that it has a singular meaning and a singular use.

The following table provides some examples of technical vocabulary in chemistry:

Table 2. Examples of Chemistry-specific Vocabulary

Technical Word	Its Meaning
Acid	A substance that dissociates in water to produce hydrogen ions (H^+) as the only positive ions.
Alkane	Hydrocarbons having the general formula C_nH_{2n+2}
Electron	A negatively charged sub-atomic particle that surrounds the nucleus of an atom.
Ion	A positively or negatively charged particle. It is formed when an atom or group of atoms loses or gains electrons.
Titration	The gradual addition of a solution from a burette to another solution in a conical flask until the chemical reaction between the two solutions is complete.

Note. From Helmenstine, (2008).

Each of these words has only one meaning which is the one mentioned in the table and it is used only in chemical contexts. It can be noticed that in the selected list of chemical vocabulary, the majority of technical words consists of nouns (names of: objects, tools, apparatus, substances, components, particles, operations and processes, etc.).

3.2.2.2. Sub-technical Vocabulary

The term *sub-technical* is preferred and used by some researchers such as "Cowan (1974), Robinson (1980), Trimble (1985) and Tong (1993)". However, others use *non-technical* ("Barber, 1962; Nation, 1990; Tao, 1994"). Still, others use the term *semi-technical* including "Johns and Dudley-Evans (1980), Farrell (1990), McArthur (1996)" (Greavu, 2005, p. 889). These three terms are used interchangeably to refer to the same category of vocabulary especially in scientific and technical contexts.

As Trimble (1985) mentions, the term "sub-technical vocabulary" was first introduced by Cowan of the University of Illinois, Urbana who defines it as "context-independent words which occur with high frequency across disciplines" (p. 391). This definition covers the words that are used in different scientific and/or technical contexts but keep the same meaning. Besides, Trimble (1985) adds the ordinary words that "occur with special meanings in specific scientific and technical fields" (p. 129). These two groups of words constitute the “English sub-technical vocabulary”. In short, sub-technical words are “those words that have one or more ‘general’ English meanings and which in technical contexts take on extended meanings (technical, or specialised in some fashion)”. (Trimble, 1985, p. 129)

According to Greavu (2005), Trimble was among the first who concluded that English sub-technical vocabulary can basically be classified into two categories. The first category is “context-independent words” that have the same meaning in several scientific or technical disciplines (such as: *function, isolate, basis, stir, boil, freeze*). The second one is “context-dependent words” that are usually common in general English but may take on unusual meanings in specific scientific and technical texts (p. 899). The word *base*, for instance, has completely different meanings across disciplines as shown in the following chart:

Base	
Botany:	The end of a plant member nearest the point of attachment to another member, usually of a different type.
Chemistry:	A substance which tends to gain a proton. A substance which reacts with acids to form salts.
Electronics:	Part of a valve [US "tube"] where the pins that fit into holes in another electronic part are located. The middle region of a transistor.
Navigation:	In a navigation chain, the line which joins two of the stations.

Figure 8. A Sample Sub-Technical Term (Trimble, 1985, p. 130)

Context-dependent words mentioned above, also referred to as “discipline-based words”, represent the words which have specialised meanings in different fields of science or technology. These specialised meanings are sometimes “metaphorical extensions” of the general or original meaning. A good example of this explanation can be the use of the word *mouse* (the rodent) to name a computer device (Blank, 1999). A particular group of words like these can be ‘polysemous’ and/or ‘homonymous’ (Marshall, Gilmour & Lewis, 1990).

In other words, sub-technical vocabulary can be seen as that type of words which have emerged between terminology or technical terms and general English words. These words are general in nature and technical in use; which means, if used in a technical context, they would have totally different meanings than in general contexts (Crystal, 1992).

Similarly, Baker (1988) refers to sub-technical vocabulary as words that are “neither highly technical and specific to a certain field of knowledge nor obviously general in the sense of being everyday words which are not used in a distinctive way in specialised texts”; i.e., “neither specialised nor general” (pp. 91-92). Likewise, Greavu (2005) states that this type of vocabulary consists of items from “normal English operating within a science context” (p. 889). They are also the most frequent type of words in any technical text; for Greavu (2005), sub-technical words are “constituting about 70% of technical texts”. (p. 890)

However, sub-technical vocabulary cannot be restricted to a particular type of words. As Baker (1988) puts it, sub-technical vocabulary is made up of several groups of words itself. The following list is an illustration of some of these types: (This list does not represent all possible types)

1) Terms expressing concepts that are found in most or all specialised disciplines such as: *factor*, *method* and *function*.

2) Terms having a specialised meaning in one or more disciplines, in addition to a -totally- different meaning in general language. A good example can be the word ‘*bug*’. The word has a general meaning which is a small insect. In computer science, it means a coding error in a computer program. It also has a different meaning in the world of spying or

investigating, *bug* is a verb which means hide a tiny microphone in order to record someone's speech. (Baker, 1988; OED, 2011)

3) Terms having different meanings in several specialised disciplines but not used at all in general language such as the word *morphology* (in *biology*: the structure of animals and plants, studied as a science; and in *linguistics*: the forms of words, studied as a branch of linguistics). (OED, 2011, p. 827)

4) Terms usually viewed as general language vocabulary but they have precise meanings in certain specialised fields. A good example can be the word *expressive*; in general context, it means showing or conveying a feeling or thought. In botany, however, it has a specific meaning as in: *expressive* genes (vs. *masked*) which means "more apparent physically". (p. 92)

5) General language terms preferred to other semantically equivalent terms, used in describing technical processes. For instance, the word *happen vs. occur* or *take place* in the following example explains this category:

> *Photosynthesis, and other processes such as digestion, do not, apparently, ever 'happen': they overwhelmingly 'take place' and occasionally 'occur'.* (p. 92)

Happen means come into existence carrying the meaning of random or sudden; however, *occur* or *take place* means to become observable. (Cambridge, 2008)

6) Terms which are employed in specific contexts to fulfil certain rhetorical functions. These terms indicate the author's "intentions or his evaluation of the material presented". An example is the expressions used in Plant Biology which are provided by Johns and Dudley-Evans (1980): "One *explanation* is …", "*Others* have *said*…" and "It has been *pointed out* by …" (Cited in Baker, 1988, p. 92. [emphasis original]). In other words, the special reference used by authors to mention specific notions or concepts that are

understood only in that text, and thus, once they appear in another, they may have totally different meanings and reference.

It should be noted that this category cannot be limited in one finite list of words. However, it is flexible because it allows more words as far as the scientific/technical field requires and the new findings or discoveries (processes, substances, phenomena, etc.) necessitate. This is what Kam-Mei (2001) has explained stating that this category has "open boundaries which will flexibly allow for any general word that becomes technicalised and also any technical vocabulary item that becomes generalised" (Cited in Greavu, 2005, p. 890).

3.2.2.3. Noun Compounds

In addition to terminology, sub-technical vocabulary and general English words, Trimble (1985) has noticed that 'noun compounds' (also referred to as *noun strings*) frequently appear in EST discourse. He defines them as "two or more nouns plus necessary adjectives (and less often verbs and adverbs) that together make up a single concept; that is, the total expresses a 'single noun' idea" (pp. 103-131). From this definition, it can be seen that the meaning of a noun compound is -more or less- similar to the concept of a noun phrase.

In general English texts, Trimble (1985) lists eight rules that can be used to understand noun compounds. In fact, these rules contain some of the possible types of noun compounds that can be found in different contexts. From the rules, three types of noun compounds can be distinguished:

1. A group of two or more nouns in addition to necessary adjectives and articles that expresses a single concept; e.g., *the heavy chemistry laboratory equipment*.

2. Compounds formed from prepositional phrases with 'of'; e.g., *the bottom of the page*.

3. Compounds formed with relative clauses (which, who, that); e.g., *a place where wheat is stored*. (p. 130. examples added)

The same types appear to be commonly used in scientific and technical texts. These noun compounds are usually short versions of the above types (in addition to others). The full form, then, is a way to explain the noun compound as Trimble (1985) called it "translation". The following table summarises these types with illustrative examples:

Table 3. Types of Noun Compounds in Scientific and Technical Texts

Type of Noun Compound	**The short version / The Noun Compound**	**The original / the translation**
1. prepositional phrases:	- a differential time domain equation	- the time domain *of* a differential equation
2. string of prepositional phrases	- momentum transfer experiments	- experiments *of* the transfer *of* momentum
3. nouns modified by relative clauses	- automatic controller action	- controller action which is automatic
4. nouns modified by gerund phrases	- a fluid bed reactor	- a reactor *containing* a fluid bed
5. combinations of the above	- a quiescent state fluid bed reactor	- a reactor *containing* a fluid bed *which* is in a state *of* quiescence

Note. Adapted from Trimble (1985) by the Researcher.

Besides, another categorisation of noun compounds based on their length and ability to be translated or explained are provided by Trimble (1985). They can be:

(1) *Simple*: is generally formed with two nouns like "metal shaft" or "metal cutter". These two noun compounds are translated into different types of noun phrases which are respectively: a prepositional phrase in "a shaft made of metal", and a phrase built with a relative pronoun in "an instrument which is used to cut metal". (p. 133)

(2) *Complex*: contains more than two nouns such as "liquid storage vessel". In this example, there are three nouns. The problem with this type (that may face non-native students) is it might be mistranslated because the main noun in the string is not obvious (the other nouns act like adjectives). So, it is translated "a vessel for storage of liquids" and not the vessel which is liquid here.

(3) *More complex*: compounds cause problems to even native speakers; they are usually composed of more than three nouns (sometimes adjectives as well) which makes it difficult to understand the relationship between the nouns. They are generally misinterpreted especially by non-experts in the field. Therefore, they require thorough knowledge of the field in which they are used in order to be correctly paraphrased. For instance, the noun string "aisle seat speech interference level" cannot be -effortlessly- translated or paraphrased by non-professionals in airplane manufacturing. Hence, it indicates "acoustic tests made to determine the level of interference with speech between an attendant and a passenger who is sitting in an aisle seat". (p. 134)

(4) *Very complex*: noun compounds are not quite different from more complex ones above. They are long strings of nouns with necessary adjectives and usually with no preposition or conjunction that show the relationship between the nouns. It is recommended then to be explained by their original writers. For this compound, for example, "a heterogeneous graphite moderated natural uranium fuelled nuclear reactor" the best way to interpret it could be the use of "a few punctuation symbols" in order to show which words modifies the other(s): "a heterogeneous, graphite-moderated, natural-uranium-fuelled nuclear reactor" (p. 134). It is noticed that these types are commonly found in technical dictionaries.

Earlier on, Bartolic (1978) finds that "a greater number of nominal compounds have developed from the post-positional phrases which in a deeper analysis might be logically deduced as shortened forms of definitions" (p. 258). This kind of definition is well-known and frequent in EST discourse. It can be said that it is correspondent to most of the types mentioned above, most possibly to those built with a relative pronoun. Master (2003) has explained how these definitions are formed. In scientific and technical texts, a definition of a substance, instrument or process usually contains three main elements which follow the structure: “A is a B that C” in which:

A (species being defined)

B (the group or class to which the species belongs)

C (differentiating characteristic) (p. 3)

Then the sentence: “Carbon (A) is an element (B) that is found in all living things (C)” is a sample definition that follows the above structure. The C component can be the answer to one of the following questions:

1. What are its characteristics? (Properties)
2. What is it composed of? (Material)
3. How does it work? (Operation)
4. What does it do? (Purpose)
5. Where is it used/found? (Location)
6. When is it used? (Time)
7. What does it resemble? (Shape/form)
8. Who discovered/uses it? (Inventor/Professional user). (Master, 2003, p. 3)

Putting it altogether, a noun compound can be defined as “a grammatical structure in which nouns are linked together to indicate a new concept” (Master, 2003, p. 2). Simplifying this, a noun compound or a noun string can be translated or “back-formed” into a noun phrase in order to explain it into an unambiguous way (Trimble, 1985, p. 131). It is commonly used in general English as it is particularly “prevalent in professional texts in science and technology, business, medicine, law, and other areas of English for Specific Purposes (ESP)” (Master, 2003, p. 2). Such type of texts necessarily imposes the use of new terms along with their definitions; thus, noun compounds are frequently employed.

Starting from these facts, noun compounds can belong to either of the previous categories of vocabulary in EST texts; they may have general use or technical meaning as they may be in between. However, they can be a separate category of their own (as suggested by Trimble, 1985). Therefore, it can be concluded that vocabulary in EST discourse is classified into four major categories: *terminology* (technical vocabulary), *sub-technical vocabulary*, *ordinary English* and *nominal compounds*. The following diagram summarises these categories:

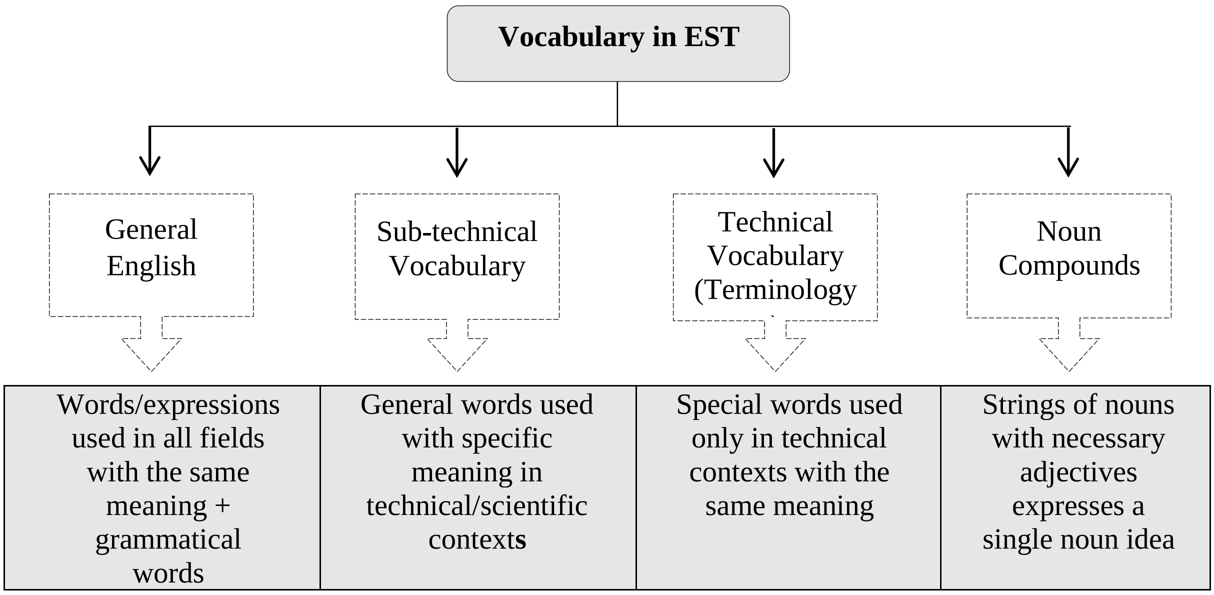

Figure 9. Types of EST Vocabulary (By the researcher)

3.2.3. Lexical Problems in EST Discourse

According to Meara (1980), vocabulary has always been recognised as (NNS) learners' greatest source of problems. Probably, the major reason lies in the fact that unlike syntax and phonology, vocabulary does not have 'rules' that learners are supposed to acquire in order to develop their knowledge about the language. That is to say, in a second and/or foreign language vocabulary learning, it is not clear what rules to apply or what -type of- vocabulary to start with. As stated by Oxford (1990), vocabulary is "by far the most sizeable and unmanageable component in the learning of any language, whether a foreign or one’s mother tongue, because of tens of thousands of different meanings”. (p. 23)

Similarly, on the basis of current research, Berne and Blachowicz (2008) indicate that vocabulary might be problematic not only for learners but also for teachers of a second/foreign language because “they are not confident about the best practice in vocabulary teaching and at times do not know where to begin to form an instructional emphasis on word learning” (p. 315). In addition, vocabulary knowledge has a direct relationship with language use, and this relationship is translated in the fact that a difficulty in the learning of vocabulary may lead to shortage in language use.

For most non-native speakers who communicate their scientific findings in English, the influence of their mother tongue or any other language they master (such as the case of the subject of this research: Arabic and French respectively) creates difficulties particularly at the level of vocabulary. Therefore, aspects like “word meaning, idiomatic constructions, multi word items to name just a few” appear as problems caused by differences between the languages. These aspects “can seriously hinder comprehension” and prevent correct, clear communication. (Greavu, 2005, p. 889)

Another problem may be due to the fact that in an attempt not to repeat words or phrases, students sometimes fall in the mistake of wrong word choice which may change meaning and create ambiguity. In scientific writing in particular, using each time a different name for the same object, concept or tool will definitely confuse readers thinking that there are many of these used. Therefore, it is preferable to repeat words or expressions than to use synonyms and make their writings ambiguous and vague. Writers are then advised “on a similar note, [to] consistently use the same word to describe the same thing in order to provide continuity and avoid confusion”. (Derish & Eastwood, 2008, p. 52)

Examining scientific papers reveals that science students, especially NNS, have problems with word choice. Vainre (2011) mentions that science writers must know that "avoiding excessive stylistic flourish and unnecessary details, which extend the text or reduce its clarity, is a prerequisite" because using unclear and vague expressions as well as 'wrong' selection of words lead to "blur legibility and penetrability of the text". According to Aaronson (1977), it is "unfortunate that so many of us devote so little attention to our choice of words" (p. 6). For example, the words '*while*' and '*since*' have primary time-related meanings, but *while* is often used as a synonym for 'although' or 'whereas' and *since* is usually used instead of 'because'. The problem is that most of these students are not aware of this fact and thus misuse both words. (Derish & Eastwood, 2008)

Science students also make the mistake of using long, big words in order to impress readers which is a wrong thought and unaccepted in science communication. For example, they use words like *usage* instead of *use* and *methodologies* instead of *methods* sometimes without differentiating between each pair.

Correspondingly, word choice and types of vocabulary used have a direct impact on the readability of the written text. Plaxco (2010) has observed that the extensive use of jargon is the first and the greatest enemy of clear scientific writing. Wrong choice of words also affects the precision and accuracy of the text which makes it hard to be read and difficult to be understood. It also causes ambiguity that imposes extra efforts on readers in order to decode and grasp the meaning being conveyed correctly and exactly. Therefore, it is recommended for science writers to choose clear, simple words instead of complex ones.

Contrariwise, many scientists believe that they had better sound scientific. This usually means using scientific jargon instead of basic, plain language. Aaronson (1977) -defending the use of scientific jargon- claims that "it allows greater brevity and exactitude than ordinary language". Jargon and technical terms cause science to be beyond the understanding of non-peer scientists which makes them develop the impression that only scientists (peers and experts) can understand "the deep mysteries involved". (p. 6)

When the problem of wrong word choice meets the willing to impress or show off in science communication, the use of unnecessary words appears. Writers use two words or more where one is enough; words that can be synonyms or one indicates the other. For instance, the words *completely* and *utterly* are synonyms; therefore, '*completely and utterly alone*' means the same thing as '*completely alone*', which means the same thing as '*alone*'. (Sheffield, 2011. [emphasis added])

As noticed also, one major source of needless words was "*ineffectual phrases*", i.e., phrases that add no meaning to the text. Sheffield (2011) says that "the intent of those who use ineffectual phrases is to make it appear as though their sentences are more substantial than they actually are, but not one sentence is made more meaningful by their inclusion". For example, phrases like "*it should be noted that*", "*the thing about it is*", "*the fact of the matter is*", etc. add nothing to a scientific writing and thus should be avoided (p. 18). This type of phrases -in addition to repeated phrases- is considered "enemies of good writing". That is to say, even if these sentences may seem to add sense or finesse, they de facto "can do more harm than good" to the style or meaning of the text being written and make it rather "redundant" because they "only tend to give a false depth and emphasis to what is being said". Sheffield (2011) provides some of the commonly occurring ineffectual phrases and how they can be replaced or avoided: Use "*actually*" instead of "*as a matter of fact*", "*because*" instead of "*due to the fact that*" or "*by virtue of the fact that*", and "*except*" to replace "*with the exception of*"; and simply drop expressions like "*it is interesting to note that*", "*needless to say*" and "*when all is said and done*". These expressions are also referred to as "multi-word phrases that mean nothing more than a simple word". It is also recommended to "never use a complex word when a simple word will do" such as *most* and *can* should be used in place of *a large majority of* and *has the capacity to* respectively. (Orwell. Cited in Sheffield, 2011)

Furthermore, Plaxco (2010) has observed that some science students and writers make excessive use of unnecessary adverbs and adjectives such as ‘fundamentally’, ‘very’, and ‘great’ despite the fact that it is advised to use such adjectives and adverbs ‘frugally’. The adverb ‘*very*’, for instance, is one of the most overused adverbs, as mentioned by Sheffield (2011): “every experiment is ‘*very innovative*’, every result ‘*very interesting*’, and every conclusion ‘*very important*’.” Sometimes *extremely* is used instead of *very* when these writers feel it is not enough. However, they should understand that such words “can be omitted without effect” unless they are necessarily used to differentiate between groups like “*high-frequency*” and “*very-high-frequency*”. Additionally, science writers should also be careful with other adverbs like *obviously*, *clearly*, or *undoubtedly* because it is not necessary that what is obvious to the writer is obvious to the reader. (Sheffield, 2011)

Furthermore, Trimble (1985) addresses three different areas of lexical problems related to the types of EST vocabulary mentioned earlier. These difficulties are: (1) “weaknesses in memorising”, (2) “newly named field of sub-technical vocabulary” and (3) “the less technical noun compounds”. The problem of memorising sub-technical vocabulary and noun compounds in EST discourse is due to the fact that they differ from one text to another (depending on the context of each text). Dictionaries do not provide any definition for semi-technical terms; only dictionaries of technical words are available. NNS students have their own techniques to overcome this shortage; they depend on their knowledge of the language (English) and the field of interest (e.g., chemistry, physics, etc.). Those who have a good knowledge of both will create their own definitions. Whereas, those with less knowledge will ignore or skip the difficult words which lead them to misunderstand the provided meaning of the terms and may be the whole text.

Another problem risen with noun compounds is that many of them can neither be understood by being divided into its compounds nor be translated into the students' native language. Sometimes if translated, the version would be totally different from the original. Even native speakers of the English language who are not familiar with the subject matter face problems to interpret and decode noun compounds.

Earlier on, Herbert (1965) mentions that the real problem is not with technical vocabulary. Much more difficulty is that caused by "the semi-scientific or semi-technical words, which have a whole range of meanings and are frequently used idiomatically". For instance, words like "*work*, *plant*, *load*, *feed* and *force*" appear to be harmless and simple; however, they can create difficulties and cause misinterpretation for science students whether they are native or non-native English speakers. (Cited in Pearson, 1998, p. 18)

Similarly, Boyle (1993) refers to this problem as the 'top' of the difficulties faced by learners of English for the scientific purposes. However, he states, as a result of his own experiment, that science students, who were able to overcome this difficulty and gained good knowledge and use of scientific vocabulary, have a better performance with EST texts rather than with general and/or literary texts. One major reason for that is "the range of vocabulary and sentence structure" that differs in scientific contexts from that in general ones (p. 228). In other words, scientific English has -more- precise vocabulary and thus, students know their exact categories and uses.

In addition to the choice of words and types of vocabulary, lexical difficulties appear in relation to content. Learners may face a lexical problem at the beginning of a text or at the level of the transition between sentences. Fulcher (1997) states that "it is necessary to make this connection before the text can be comprehended, and even for good readers, it may be necessary to re-read the first sentence to make sense of the second" (p. 119). This problem can be due to poor organisation of texts, and/or misuse of transition and link words. This is true of most sentences. While there is no required vocabulary that makes a clear structure to the text and presents markers needed for interpretation, it is essential for the reader to continually make inferences of this kind which may be potentially ambiguous. Relations between propositions need to be visibly marked in written texts with the appropriate words.

Technical vocabulary creates fewer problems compared to sub-technical vocabulary. These in-between words, neither purely technical to a specific field nor commonly general, shape the biggest obstacle in front of students willing to understand technical texts. Non-native learners do not usually have a problem with highly technical words since they are generally taught directly and explicitly by teachers of the specific field being studied or available in dictionaries. NNS students of EST who were confused with sub-technical vocabulary and noun compounds -with which they are unfamiliar- used to check dictionaries, which did not provide much help for them. Therefore, it is suggested that teachers of EST had better be qualified in science and technology in order to be able to explain the concept of sub-technical vocabulary and how it should be dealt with and that this area of semi-technical terms has to be given more focus. The word *fast*, for example, is used with different meanings; in the medical field, it means 'resistant to' while in the mining field, it means 'a hard stratum under poorly consolidated ground' (Trimble, 1985, p. 130); and these two meanings differ from the ordinary use of the word: 'quick'. Students, "unaware of the fact that familiar words may have very unfamiliar meanings", take it for granted that they already know them, expecting the general English meaning to make sense in any context. (Trimble, 1985, p. 129)

Likewise, Nation (2001) explains that sub-technical terms cause more difficulty than technical words do because they are "by definition, polysemous" i.e., it is not easy for students to memorise the several meanings these words have and which differ from one scientific field to another. Therefore, it is suggested "to identify them and systematically teach them" (p. 7). Bailey (2006) also notes that "60 to 70 percent of English words have multiple meanings depending on the context" (p. 19).

Word knowledge is already complex, and this polysemous factor contributes to the difficulty of EST learning especially for learners who may be familiar with the common use of a word but may not understand its usage in specific contexts. This problem goes back to the fact that not enough light has been shed on the area of sub-technical vocabulary by both teachers and learners. Science and technology writers, then, misemploy these context-dependent words with a totally different meaning which is one main reason behind the misunderstanding of texts that causes by itself another problem for science students.

It can be said that almost all the aforementioned problems, that are created by or related to sub-technical words, go back to the difficulty in setting the -final- limit between general and specific vocabulary, and how to teach what comes in between. Sub-technical vocabulary covers every item which is neither too general nor very specific is categorised.

The other type of EST vocabulary that causes trouble to NNS learners of English is *noun compounds* (Master, 2003). This category is not common in all languages. That is why noun compounds are difficult to be translated into students' first language (unless it is Germanic). If tried, the result would be 'long and unwieldy phrasing'. Students -with an adequate level in English- tend to find their own ways of understanding noun compounds such as breaking the compound into its component parts (nouns, adjectives, verbs, preposition, etc.) and explain or translate each part alone into their language. However, this technique cannot be applied to all English compounds. For instance, while compound nouns like 'copper wire' and 'steel wire' mean wires which are made respectively of copper and steel, 'piano wire' does not mean a wire which is made of piano! These are only simple two-word compounds. More complex ones cannot be translated in such way, especially in scientific and technical contexts in which it can be often impossible even for native speakers who are unfamiliar with the subject. Therefore, it can be concluded that the complexity of noun compounds and the difficulty to be translated or explained have a positive relationship; in other words, the more the compound is complex, the more difficult its translation becomes. (Master, 2003, p. 131)

3.3. Syntactic Features: Grammar

After vocabulary comes grammar, another aspect of language which is as important in language learning and communication. It is the glue that binds together the words and converts meanings. In the importance of grammar, Wilkins (1976) writes: "The learning of a language is most commonly identified with acquiring mastery of its grammatical system" (p. 1). It is the system of rules that governs how the language is used. This system, together with other features such as punctuation and cohesion, is significant in controlling correctness of utterances and avoiding arbitrary expressions. It is evenly and simply the word for the rules that people follow when they use a language.

Furthermore, Wittgenstein (n.d.) states that the role of grammar in language or language learning is descriptive rather than being explanatory. Grammar "does not tell us how language must be constructed in order to fulfil its purpose, in order to have such-and-such an effect on human beings. It only describes and in no way explains the use of signs" (Cited in Bindemen, 2017, p. 83). Therefore, it can be said that grammar rules are needed "to guide us in the usage of words", they are "not stationary" because "language is a living thing, and its rules are fluid". (Bindemen, 2017, p. 83).

Grammatical aspects are not used in all contexts with the same frequency. Some aspects might be more frequent than others depending on the context being addressed. For example, the second conditional (which is used to express an improbable future event or situation) is frequent in science-fiction context (Foley & Hall, 2003) and, maybe, not used at all in purely scientific contexts. In other words, there is no specific grammatical aspects in a specific field; there is rather the choice of some aspects over others. In English for scientific writing, for instance, some grammatical aspects are more frequent than others. The selection of some features is due possibly to the fact that scientific writing has its own style and its own characteristics; i.e., in order to achieve the accuracy, conciseness and objectivity of EST writing, some aspects are preferred to others. These preferences require careful study because most science students and writers are unaware of them or have false thoughts about them (e.g., the use of *passive voice* as shown further).

3.3.1. Sentence Structure and Subject-related Problems

3.3.1.1. Defining the Sentence

A sentence is defined as a group of words with a subject, verb and a complement that are logically connected. As a matter of fact, this definition is not totally reliable. Putting a group of words together in a sequence or string to form a sentence should not be arbitrary or random; it rather follows what is known as grammatical or syntactic structures. Syntactic structures are concerned with three main points: (1) “analysing linguistic expressions into their CONSTITUENTS”, (2) “identifying the CATEGORIES of those constituents,” and (3) “determining their FUNCTIONS”. If any group of words is put in a linear form together to make a sentence just as the above definition suggests, then “the possibilities are endless”. Not all possibilities are correct or acceptable just like the example: “disappears non girls of the students”. (Burton-Roberts, 2011, p.7. Original capitals)

Precisely speaking, Bloomfield (1955) defines the sentence as “an independent linguistic form, not included by virtue of any grammatical construction in any larger linguistic form”. In other words, a sentence is a set of words which are joined together with certain grammatical relationships, and which do not depend on another set to be interpreted and understood, for example: "*How are you? It's a fine day. Are you going to play tennis this afternoon?*" (p. 170).

Furthermore, Lyons (1995) defines the sentence as "the largest unit of grammatical description". It is a unit between "the constituent parts of which distributional limitations and dependencies can be established, but which can itself be put into no distributional class" (pp. 172-173). In other words, the constituents are words which are classified whether according to their function or to their types, but the sentence is not classified in a similar way.

Concerning functions, most sentences in English are composed of two main parts no matter how many words it contains. These two parts are "subject and predicate". The subject, as Burton-Roberts (2011) explains, is used to "indicate something"; it mostly "identifies what the sentence is about". The predicate is used to "comment on the subject"; it rather "identifies what's being said about" the subject. The predicate is the part of the sentence which modifies the subject and which contains or is usually represented by a verb. This division does not work for all sentences in English since there are other types and structures; however, this is a common one as shown in the following examples:

Subject	**Predicate**
Ducks	paddle.
The ducks	are paddling away.
Those gigantic ducks	were paddling away furiously.
The mouth-watering duck on the table	won't be paddling away again.

Figure 10. Subject-Predicate Examples (Adapted from Burton-Roberts, 2011, pp. 24-5)

The predicate explains or gives details about the subject; therefore, their relation should be stated so clear that the sentence can be interpreted correctly. In science, this relation is sometimes difficult to be found. The subject of the sentence can express: an object (tool, instrument, device …), a process, a methodology, an equation, a solution, a chemical substance, symbols, etc. For that reason, it can be longer than usual; the reader can be lost trying to find the verb or the predicate. Even science students and/or writers usually find difficulty to clearly state the relation between the subject and the predicate. Such long subjects may contain several types of words including: nouns, pronouns, adjectives, adverbs, participles, relative clauses, some forms of verbs, etc. the verb (usually a single word) can be buried in the sentence and its finding becomes somehow difficult. Such a problem affects the meaning of the sentence or even the whole text.

3.3.1.2. The Problem of Length

Scientific writing must be clear and precise, yet it requires a satisfactory number of details. However, the description of objects, entities and procedures usually leads to complex sentences which express several ideas without a stop or a break point. The following sentence illustrates this idea:

- The osmoregulatory organ, which is located at the base of the third dorsal spine on the outer margin of the terminal papillae and functions by expelling excess sodium ions, activates only under hypertonic conditions. (Ernst-Slavit & Egbert, 2010).

The first problem within this sentence is that the distance between the subject and its verb is quite long; the subject in this sentence is "*the osmoregulatory organ*" and the verb is "*activates*". The reader then has to go through a lot of ideas before s/he can find what happened to the subject or where the main idea is. The second problem is the number of verbs; there are three verbs in the sentence: *is located*, *functions* and *activates*, which may cause confusion to readers especially that the three verbs agree in number with the subject. Revising this sentence and solving both problems result in:

- Located on the outer margin of the terminal papillae at the base of the third dorsal spine, the osmoregulatory organ expels excess sodium ions under hypertonic conditions. (Stiles, 2014)

The subject becomes closer to the verb and the confusing verbs are revised and repositioned. In addition to that, the sentence is now shorter than it was before (27 words instead of 34).

It can be said that long subjects are frequent in science communication because ideas and concepts in science cannot usually be expressed in one word. This is more or less similar to the concept of noun compounds mentioned earlier. That is what Li and Li (2015) explain stating that "Science and Technology is the study of the development, distribution, structure and function of the living things in the outside world, which lie together in interrelated, paradoxical movements". In order to present the sophisticated relations among such entities, EST writing "greatly depends on the logic thinking that resort to the linguistic form", which is "long and complicated sentences consisting of clauses and phrases that are mutually conditioned" (Li & Li, 2015). Scientific writing is rich in long and complex subjects. The biggest problem they cause is making the distance between subject and verb large and confusing as shown in the example above. (Sheffield, 2011)

Long sentences containing long subjects confuse both writers and readers. The former can fall in the mistake of disagreement between the subject and the verb (which is another grammatical problem to be discussed further). The latter may not understand what the real subject is or who the actual doer of the verb is, or even what the main verb of the sentence is. Possible solutions might be getting rid of unnecessary words and phrases, replacing phrases with a single word (when possible) and -maybe better- breaking complex sentences into short, simple ones. However, it should be noted that sentences which are too short, poorly connected and incoherent can be annoying to read. In contrast, sentences that are too long and confusing are difficult to follow. Therefore, sentence length should be carefully managed in order to allow ideas to flow clearly (Sheffield, 2011). In order to do so, he adds:

> Often, science writers want to accomplish too much in a single sentence: define a complex abstract entity (the subject), and then describe something that it does. Instead, it is usually clearer to split these tasks into multiple sentences, some to define the subject and others to describe what it does.

Short or long: Which is appropriate? On the one hand, long sentences are problematic for the reasons mentioned so far and thus science writers are advised to avoid them. A course presented by Doumont (2011) explains that long sentences “tax readers’ short-term memory” before they even understand them or know what to do with them. In other words, it is better to “keep together what goes together”. On the other hand, short sentences are not always convenient in science prose. According to Sheffield (2011), “length and complexity alone don’t make a sentence difficult to understand: some long sentences are perfectly understandable, and specialised terms may be necessary to explain complex problems”. Long, complex sentences are fine; the real problem is the way sentences are written or organised. Some short sentences containing simple words can be more problematic and difficult to follow simply because they are not well-written. Additionally, when writers put many ideas into one sentence (this is usually and particular done by science writers), readers find it difficult to follow the main concept being expressed and so do not understand what was communicated via that sentence. Therefore, what really matters is clarity.

3.3.1.3. Subject-Verb Agreement

Another noticed problem related to the sentence is subject-verb disagreement that most writers, including scientists, usually face. It is not easy as it sounds; it might be “the hardest part of the English language to master” especially for NNS writers (WhiteSmoke, 2014). This problem is due mainly to two reasons: First, in scientific contexts, the subject might be very long and compound which leads them to be confused whether the subject is singular or plural. Second, it is probably the fact that these NNS writers do not revise their grammar as they care more about content than language.

Subject-verb agreement is when the subject and the verb of the sentence agree in number (i.e., both must be singular or both must be plural). The problem of agreement is not with the past simple tense as it is with the present simple and/or present perfect tenses. In the past simple tense, the verb takes the same form with all subjects; singular and plural. However, in the case of present simple and present perfect tenses, writers should be careful whether they add the '***s***' or not to the verb, between *is/are* and between *has/have*.

Benner (2000) describes this agreement in a way that makes it easy to be memorised by writers. In the present simple, she writes: "nouns and verbs form plurals in opposite ways: ***nouns*** ADD an ***s*** to the singular form; ***verbs*** REMOVE the ***s*** from the singular form". (Taking into consideration the exceptions of plural nouns that do not take an ***s*** and that an ***s*** at the end of a word is not always a sign of noun plurality).

Some rules and specific cases that help writers avoid or solve sentence problems as such are provided. Writers should first know whether the subject is plural or singular. This is not always easy. In order to do so, it is imperative to identify the subject. For instance, the subject can "never be in a prepositional phrase or in a nonessential phrase separated from other parts of the sentence by commas" like in the following example:

- ***The toxicity*** [subject – singular] ***of*** three compounds *was* [verb – singular] measured … (Ernst-Slavit & Egbert, 2010).

There are some other cases that might not be known or cannot be noticed by all (NNS) writers. The same word can be used in different ways like in the following examples:

- ***A number of*** atoms *are* expected to remain.
- ***The number of*** atoms *is* expected to increase. (Adapted from Benner, 2000)

It seems that the only difference is in the article that precedes the word *number*: 'the' or 'a'. When "*a number of* …" is used as a subject, it is plural; while "*the number of* …" is singular.

As already mentioned, subjects in science discourse can be long as they contain many concepts such as formulas, numbers, instruments, etc. They may also contain small definitions or explanations of the main concept being described. For that reason, Aubé, Deane, Jandciu and Stewart (2016) advise writers not to "be distracted by anything that comes in between the subject and the main verb" (p. 390) like in the following examples:

- ***The supervisor***, along with several candidates, <u>*likes*</u> the work. (Singular subject and verb)
- ***The supervisor and several candidates*** <u>*like*</u> the work. (Plural subject and verb)

Writers should be aware that some nouns might imply more than one entity (person or thing) -known as '*collective nouns*'- which suggest that they are plural. However, these nouns should be "treated as singular subjects", such as:

- ***The team*** <u>*runs*</u> / ***The Physics Club*** <u>*watches*</u>. (Aubé, Deane, Jandciu & Stewart**,** 2016, p. 390)

Similar examples can be mentioned here. There are some words which appear to be plural but in fact they are singular because they refer to one entity. In other words, they are plural in form and singular in meaning such as: 'news', 'measles', 'mumps', etc. These words require singular verb form, for instance:

- Generally, ***measles*** <u>*lasts*</u> about two weeks. (Benner, 2000)

Some subjects can be composed of more than one part; usually joined by 'or' or 'nor'. In this case, "the verb should agree with the part of that subject that is closest to the verb" ("*Grammar: Subject-verb agreement*", n.d.); for instance:

- X-based methods ***or*** the Y method [plural subject ***or*** singular subject] *provides* [verb – singular] a means of …

- Neither the Y method ***nor*** X-based methods [singular subject ***nor*** plural subject] *provide* [verb – plural] a means of … (Ernst-Slavit & Egbert, 2010).

However, when the parts of the compound subject are joined by 'and', they require a plural verb ("*Grammar: Subject-verb agreement*", n.d.); for example:

- Glucose ***and*** xylose [singular subject ***and*** singular subject] *promote* [verb – plural] the development of … (Ernst-Slavit & Egbert, 2010).

Sometimes, these two parts separated by 'and' refer to the same person/thing or "is preceded by each, every, or many" or "everyone, everybody, everything, somebody, anybody". In these two cases, the verb is singular like in the following sentences (respectively):

- The X-method ***and*** only method [same thing] *is* applied in this research.
- ***Each*** molecule and liquid in this experiment *is* required to be at 0°C. ("*Grammar: Subject-verb agreement*", n.d.)

In addition to that, some subjects look plural because they are compound but in fact, they are singular. These subjects are usually connected with one of the following words "with, as well as, in addition to, except, together with, and no less than" (Ramage, Bean & Johnson, 2014). For instance,

- X product ***as well as*** its solution *is* unavailable.

In scientific contexts, subjects frequently contain numbers which refer to measurements, and quantities (Ten millimetres, 5g …). In this case, the subject is considered singular, and thus, it requires a singular form of the verb; for example:

- Next, ***5 g*** of the powder [subject – singular] *was* [verb – singular] added to … (Ernst-Slavit & Egbert, 2010).

On the other hand, numbers (in addition to indefinite quantifiers such as: half of, all, none, etc.) which refer to percentages and fractions are considered either singular or plural depending on the noun they modify. They take “a singular verb when used with uncountable nouns and a plural verb when used with countable nouns” (plural) like in the following sentences:

- ***One-third*** of this **solution** [subject – singular] *was* [verb – singular] poured …
- ***Half*** of the **plates** [subject – plural] *were* [verb – plural] measured …
- ***50%*** of the **animals** [subject – plural] *were* [verb – plural] …
- *All* the **information** [subject – singular] *is* [verb – singular] available … (Ernst-Slavit & Egbert, 2010).

3.3.2. Passive Voice or Active Voice

Voice is about a change on the structure of the sentence and on which part the focus lies: The subject or the action in relation with the object. The meaning, however, remains the same but the order of the words changes. The subject in a sentence acts; it is the agent or doer of the verb while the object is acted upon. When the voice changes, the positions of subject and object change also but their roles or functions remain the same. The form of the verb is also converted; it becomes “to be + past participle” of the main verb. The preposition “by” is added to indicate the agent who or which performs the action. The following sentences exemplify these changes:

Active:	Vitamin A	increases	the risk of hair loss.
	Subject (doer)	*Verb*	*Object*
Passive:	The risk of hair loss	is increased	by vitamin A.
	New subject (not doer)	*Verb* (to be + past participle)	*Agent* (doer)

Figure 11. Example of Active vs. Passive Voice (Adapted from: Nolan, 2016)

Since both voices are similar or they keep the same meaning, why would the choice be problematic? The issue of whether to use active or passive voice is repeatedly risen in the scientific writing more than any other context. This subject created a debate among researchers: who is in favour of active voice and who encourages the -dominant- use of passive voice in the scientific prose. Each side has its supporting arguments and evidence.

3.3.2.1. Arguments in Favour of the Active Voice

As shown in the example above, the passive voice sentence consists of more words than the active one. In addition to that, the action is not performed but received. Therefore and in order to achieve the criterion of economy in the scientific writing, active voice is more convenient than passive. Griffies, Perrie and Hull (2013) state that "the active voice will usually shorten sentences and make them more dynamic and interesting for the reader". This does not mean to avoid the passive voice completely. The passive voice still can be used in some sections of the scientific article such as "the Methods section". (p. 23)

Griffies, Perrie and Hull (2013) go to the extent that, in some cases, personal pronouns can be used in the active voice because it is clearer and avoids the excessive use of the passive voice. They state that an active phrase like '*we found that*…' can be used 'freely' since it gives "a quick signal to the reader" that the coming sentence is describing results. Such expressions are also "more concise and to the point than writing in the passive voice, as in, for example, '*it has been found that there had been*…'." (p. 23. Italics original)

Similarly, Nature journals, as reported by Hoogenboom and Manske (2012), prefer authors to write in the active voice even if this means to use personal phrases "*we performed the experiment*...". Research has shown that "readers find concepts and results to be conveyed more clearly if written directly". As a matter of fact, active voice -which includes first-person pronouns *I* and *we*- was the very first choice of scientists in the past. However, personal pronouns became less common since scientists decided to adopt a passive style. (Christiansen et al., 2007)

In addition to that, Sainani, Elliott and Harwell (2015) claim that the active voice encourages simplicity and straightforwardness. This is also required in scientific writing; for that reason, most scientific journals and writing manuals recently recommended the use of the active voice over the passive voice. The following list, for example, contains some journals and writers' guides which advise science writers to use the active voice instead of the passive voice in many parts of their papers excluding some cases or sections:

- The American Medical Association's *AMA Manual of Style*,
- The *Publication Manual of the American Psychological Association* (APA),
- *Behavioural Ecology* Manual,
- British Medical Journal,
- The Journal of Neuroscience,
- The Journal of Trauma and Dissociation,
- Nature Journal,
- Ophthalmology Journal, *and*
- Science Journal.

These journals main arguments -supporting the use of active voice- are summarised in the following points:

- Active voice is preferred to passive voice because it is direct and the actual performer of the action is clear.
- The passive voice usually fails to identify the role of the researcher responsible for observations, opinions, or conclusions.
- The structure of active sentences is more correct in some cases as in the example presented by Science Journal Online Guide: "To address this possibility, we constructed a lZap library ..." is more accurate than "To address this possibility, a lZap library was constructed ..."

Concerning the structure of the active voice sentence which is "performer–verb–receiver", Biomedical Editor (2015) mentions that it responds to the nature of the scientific prose. In other words, it is “direct, vigorous, clear, and concise”. It allows the reader to recognise “who is responsible for the action”. However, the passive voice structure (receiver–verb–performer) is rather ‘indirect’ as it can be “weak, awkward, and wordy” which is unaccepted in science.

Not far from that, the University of Leicester guide (2009) states that generally the active voice is “clearer, more direct and easier to read”. Although the passive voice can be more “appropriate in particular circumstances”, its use “can lead to clumsy and overcomplicated sentences” like in the next example:

> Passive: “*Difficulty was experienced in obtaining the product in a high state of purity*” is rather convoluted way of saying:
>
> Active: “*The product was difficult to purify*” which is a much clearer and more straightforward statement.

Nevertheless, the fact which cannot be denied here is that scientists tend to use the passive voice thinking that it helps achieving objectivity and -sometimes- it is not necessary to indicate who is really performing the action. Taking into consideration such an important detail, Derish and Eastwood (2008) in addition to Plaxco (2010) advise science writers to limit their use of the passive voice. They said that reading passive structures constantly makes readers get bored.

Similarly, Doumont (2011) explains that one of the major sources of the overuse of passive language in science is the desire and the need to achieve objectivity in scientific writing; i.e., no personal pronouns and sometimes no agent is mentioned. This is not wrong but the use of passive voice must be limited to when it is more convenient or appropriate than active voice because sentences written in the passive voice are often less interesting or more difficult to read than those written in the active voice especially when it dominates the scientific paper. The following example shows the problem of being "hard-to-read" accompanied by long subject:

> "*In this section, a discussion of the influence of the recirculating-water temperature on the conversion rate of ... is presented*"

can simply be replaced by a much clearer sentence:

> "*This section discusses the influence of ...*"

It cannot be denied that the passive voice is quite common in scientific papers; however, it sounds "distant, abstract, and stuffy". Readers (science readers in particular) prefer direct language instead of hard-work reading through too many words. (Doumont, 2011)

3.3.2.2. Arguments in Favour of the Passive Voice

It was already mentioned that passive voice is mainly used in an attempt to achieve objectivity and avoid personality. In a guide published by University of Leicester (2009) for science writers, it is stated that the passive voice is the best structure that makes writing "formal and depersonalised" especially when details about the performer of the action (the agent) are "obvious or unimportant" or even unknown (p. 15).

Likewise, Gopen and Swan (1990) claim that the passive voice meets the requirements of scientific writing since it is considered 'objective' and 'impersonal'. In view of these criteria, the passive voice "became the standard style for medical and scientific journal publications for decades" (p. 552). That is to say, the wide use of passive sentences actually fulfils the needs of scientific language because of objectivity and coherence. (Li & Li, 2015)

The problem with the passive structure is that it adds complexity which is needless in scientific writing. However, it is useful especially when describing experimental procedures. This is due mainly to the fact that the experiment must be able to be reproduced; duplicated (detailed earlier in this research), and, thus, it is not important to mention the performer. For example, a chemist would write: '*The solution was heated at 100 °C for 20 minutes …*' rather than writing '*I heated the solution at 100 °C for 20 minutes…*'

Therefore, it can be said that the importance of using passive voice in the scientific discourse cannot be denied. However, it should not be overused or dominant in the whole paper; it should be used only when required. Nolan (2016) abridges and exemplifies when to use the passive voice in the following list:

1. To emphasise the product (receiver) rather than the agent (performer)

The risk of hair loss [product] is increased by vitamin A [agent].

2. To keep the subject and focus consistent throughout a passage

Female pattern hair loss is common but estimates of its prevalence have varied widely. The risk of female pattern hair loss is increased by vitamin A.

3. If you do not wish to name the subject

The procedures were somehow misinterpreted.

4. To describe a condition in which the actor is unknown or unimportant

Every year, thousands of people are diagnosed with cancer.

3.3.3. Tenses in the Scientific Paper

3.3.3.1. Tenses in English

In the English language, verbs do not only indicate the action (or state) being performed; it also indicates or denotes the time when this action is performed. Even if there is no word or expression that indicates time in the sentence, it can be recognised through the different verb forms which are known as *tenses*. Generally, there are three broad categories (related to time) into which tenses can be classified: (1) Past Tense, (2) Present Tense, and (3) Future Tense.

In addition to that, there are other aspects related to the nature of the action indicated by the verb. These aspects are mainly: *simple* (*indefinite*), *continuous* (*progressive*), *perfect* (*complete*) and *perfect progressive* (Joshi, 2014). Accordingly, there are twelve (12) different tenses in English which are listed as follows:

Present Simple	Past Simple	Future Simple
Present Continuous	Past Continuous	Future Continuous
Present Perfect	Past Perfect	Future Perfect
Present Perfect Continuous	Past Perfect Continuous	Future Perfect Continuous

Figure 12. The English Twelve Tenses

The tense of a verb reveals the 'timing' of the expressed action. For instance, past tenses indicate that an action is already done, present tenses show that the action is happening or occurring now, and future tenses demonstrate that the action did not happen yet. (Mudrak, 2012)

In addition to time, the choice of the tense shows whether the action (represented by the verb) is "**open** or **closed**". *Open* means the action is still happening or is valid while *closed* means it is over. The examples below clarify how an action or event can be 'open' or 'closed':

"*How long* ***were*** *you at Melbourne Uni?*"

The verb in this sentence is in the past simple tense. The event represented here is closed: the person "*you*" has already graduated from the Melbourne University. However, if the tense is changed into present continuous:

"*How long* ***have you been*** *at Melbourne Uni?*"

The event then is open: the person "*you*" is still a student (or a teacher) at the mentioned university. ("*Using tenses in scientific writing*", 2012)

3.3.3.2. Tenses in Scientific Writing

Generally speaking, in several types of scientific writing, many time structures are more frequently used than others. In other words, in scientific writing usually, not all tenses are used; it is preferable to use simple tenses than compound (perfect/continuous) because the focus is on the meaning being conveyed and not on the tense or time. Hence, the most frequent tenses are *present simple* and *past simple* for two main reasons: the former is used to state facts (that are generally true all the time) -which shape a great deal of the scientific prose- in addition to the conclusions drawn from the experiment or whatever scientific activity under investigation. The latter is used to describe the methods, materials and experiments which were already done. However, it is not possible or accepted to use only one tense all over the scientific paper. ("*Using tenses in scientific writing*", 2012)

The reasonable use of different tenses (usually simple) can help to clarify the three main stages of the scientific research: First, the past tense to express what happened or what the researcher did -in the past- including materials and methods. Second, the present tense is used to state what the researcher concludes from his/her investigation. Third, the future tense is used to expect or show what will be as a result in the future or how this work can be used. The following example (a summary) illustrates how the three simple tenses can be properly used together:

> The experiment **was carried out** in a sterile environment *(past tense for a statement of what happened)*. It **is** particularly important to avoid contamination *(present tense for a statement that is a general* '*truth*'*)*. It **will be** necessary to ensure that the same conditions are replicated in future experiments *(future tense for a recommendation for the future)*. (University of Leicester, 2009)

Li and Li (2015) confirm that simple tenses are generally used (mostly the simple present and simple past tenses) in order to “create timeless notions” which are required in EST writing. The reason is that the main aim of scientific writings is “to objectively state the facts, describe the process, and illustrate the features and functions, most of which are of university, frequency and particularity”.

However, this mixture of tenses should not be arbitrary; it should rather be done carefully. According to Aubé, Deane, Jandciu and Stewart (2016), “the most important thing is to be able to recognise when the tense shifts” (p. 390). Any unclear, incorrect use of a tense -instead of another- can confuse readers and that is not accepted in science communication. It is important then to be consistent and correct in choosing the proper tenses when describing the different steps of investigation.

Therefore, science writers should pay attention to the tenses they use in each step of their paper. Plaxco (2010) believes that “most observations reported in the scientific literature are better described in the present tense” because -taking into consideration that scientific experiments can be duplicated- “the observation remains true even after the experiment was performed”. (p. 2261)

Similarly, in science writing in general, there are two dominant tenses: the present tense (usually simple) and the past tense. The present tense is preferred when expressing “known facts and hypotheses”. For instance, the sentence “*the average life of a honey bee* <u>*is*</u> *6 weeks*” provides a fact. The past tense is used for “describing experiments that have been conducted” as in: “*All the honey bees* <u>*were*</u> *maintained in an environment with a consistent temperature of 23 degrees centigrade*…” in addition to “the results of these experiments” as in: “*The average life span of bees in our contained environment* <u>*was*</u> *8 weeks*…” (“How to get your article published”, 2010). Other tenses may occur but less frequently.

Table 4. The Different Uses of Simple Tenses in a Scientific Paper

Tense	Uses	Examples
Past Simple	- Work done - Work reported - Observations	- Blood samples <u>*were*</u> *collected* … - Jankowsky <u>*reported*</u> a similar growth rate … - The number of defects <u>*increased*</u> sharply
Present	- General truths - Atemporal facts	- Smoking <u>*increases*</u> the risk of coronary heart disease - This paper <u>*presents*</u> the results of …
Future	- Perspectives	- The influence of temperature <u>*will be*</u> the object of future research

Note. Adapted from Doumont (2011)

The choice of the appropriate tense is of a serious necessity; it should be carefully done. The difference between the two sentences below is the tense:

a- “The temperature *increased* linearly over time”.

b- “The temperature *increases* linearly over time”.

Sentence (a) is in the past simple tense. It represents a particular observation in a specific experiment. Sentence (b) is in the present simple tense which indicates a fact rather than an observation. It may also refer to a generalisation of the experiment result which suggests that the temperature *always* increases in a linear way in certain experimental circumstances.

Another detail that could be mentioned here is that sometimes, in complex sentences, two different tenses can be combined. For example, “In 1905, Albert Einstein ***postulated*** that the speed of light ***is*** constant …”. In this sentence, the first verb is in the past simple because the action happened in the past (in 1905). The second verb ‘*is*’ expresses a scientific fact and thus it is in the present tense. (Doumont, 2011)

3.3.3.3. Tenses in the Scientific Article’s Sections

After stating tenses in scientific writing in general, it is important to identify tenses in the scientific article in particular for two main reasons. First, the scientific article is the major concern of this research paper and it is what the target population of this work has to write in English. Second, the use of tenses in scientific articles requires careful study. The use and occurrence of tenses in the scientific article differ from one section to another. As reported by Joshi (2014), “a typical research paper follows the IMRaD format, and how frequently a given tense is used varies with the section of the paper”. The frequency of tenses can also vary between “one scientific discipline and another” in addition to journals and types of articles. (“*Using tenses in scientific writing*”, 2012)

The choice of an appropriate tense is considered one of the biggest problems that face writers of scientific articles. Being confused about that, most of them use only one tense dominantly (either present simple or past simple) in the whole paper and one voice (passive voice). Most of science students imitate other papers when they write thinking that it is the best way to avoid as many mistakes as possible especially when it comes to tenses. In contrast to what they think, they fall in more mistakes than ever: Incorrect tense forms and uses; subject-verb disagreement; misplacement of the verb and other words like adjectives and adverbs; in addition to wrong punctuation and general sentence structure (compound, main or subordinate clause’s main idea).

As stated earlier, the language is as important as the content in scientific articles and language mistakes may prevent good-content articles from being published. Therefore, every single sentence should be carefully revised before submission. It should be taken into consideration that wrong tense choice, among other aspects, do not only affect the language; it may change the intended meaning or lead to ambiguity. That is why it is emphasised by journal experts. Carraway (2006) mentions that “editorials in several journals have noted that proper verb tense is an important aspect of a well written manuscript”. (p. 384)

Each section in the scientific article describes one step of the research and thus includes different types of information. Therefore, each section requires a particular tense form to express this type of information appropriately. Lin and Kuo (2012) state that "choosing the correct verb tense for each section of a scientific manuscript can be challenging, but it is worth the effort" (p. 80).

The following table summarises the tenses used in each section of the scientific article and the reasons behind using them.

Table 5. Tenses in the Sections of the SA

Section	Tense(s)	Reason(s)
Abstract	-Past tense (past simple or present perfect)	It is a summary of the entire article
Introduction	-Present simple -Present perfect	-includes background knowledge accepted as facts -refers to the current research -currency and recency
Methods	-Past simple (Usually passive form)	To report what was done
Figures and diagrams	-Present simple	These illustrations are present in the article; use verbs such as: demonstrates, shows, displays …
Results	-Past simple	The obtained results and findings
Discussion	-Present simple -Past simple	-To explain significance of the results -To interpret the results -To summarise the findings
Conclusion	-Combination of tenses: -Past simple -Present simple -Future Simple	To highlight past research and future directions -Summarise findings -Explanation and opinion -Further suggested studies

Note. From Swales and Feak, (2004, p. 254)

3.3.3.3.1. Tenses in Titles and Abstracts

Titles usually do not contain a conjugated verb. It is not required to write the title in the form of a complete sentence, so usually no verb is needed like in: "*Investigating the Role of Academic Conferences on Shaping the Research Agenda*". However, the title can sometimes be a full sentence or a question which require conjugated verbs such as "*Academic Conferences Shape the Short-term Research Agenda*" and "*Do Academic Conferences Shape the Research Agenda?*" (Jamali & Nikzad, 2011. Cited in Derntl, 2014,

p. 109). The most frequent tense in such cases is the present simple. The present simple passive can also be used. (Derntl, 2014)

On the other hand, the *Abstract* is a complete paragraph; and a paragraph is made up of full, complete sentences. Automatically, there are plenty of conjugated verbs in the abstract. Basically, the abstract "comprises a one-paragraph summary of the whole paper" (Derntl, 2014, p. 109). In other words, it summarises the content of the paper including the objectives of the research in hand, the methodology being employed to answer the question(s) of the research and the main results obtained. (Day, 1998)

For that reason, more than one tense form is used. Mudrak (2012) explains that "the verb tense chosen for the abstract should be based on the section of the text to which each sentence corresponds". The abstract comprises a brief extract from each section of the paper. Therefore, an abstract, according to APA (2010), "should be written in present when discussing results or conclusions and in past tense to describe methods or measurements taken, but not in future tense" (p. 27). Another tense that may appear in the abstract of scientific papers is the present perfect which is used to refer to previous researches (Mudrak, 2012). An example reported by Salager-Meyer (1992), "one study of verb tense in English medical abstracts has revealed that the three most commonly used tenses are past, present, and present perfect". (p. 95)

3.3.3.3.2. Tenses in the Introduction

As stated earlier, the *Introduction* of a scientific article comprises two main types of information: first, background knowledge usually presented through a summary of previous work on the subject being investigated; second, the importance of the research. The former (commonly known as *Literature Review*) contains information that is usually considered as facts. Therefore, the most appropriate tense for this part is the present simple even if the cited works have been already done. The present perfect can also be used to cite previous researches in the purpose of communicating ‘recency’ and ‘currency’ (Swales & Feak, 2004). For the same purpose, the latter is best expressed in the present simple tense as well.

Similarly, Swales and Feak (2004) have written that the nature of information included in the Introduction requires two main tenses: *present simple* and *present perfect*. The present simple tense indicates that the research results and findings are original, true and valid. For example, the present simple shows that this sentence is always true: “Genomics ***provides*** crucial information for rational drug design”. (“*Using tenses in scientific writing”,* 2012)

Another tense that may appear in the Introduction is the *past simple*. Some authors or journals prefer to use the past simple to cite previous related researches. However, the present perfect is better than the past simple because it is “considered more relevant to the situation now than the event”. (Štětinová, 2010, p. 436)

Therefore, in the Introduction of a scientific article a mixture of tenses is used including the present simple, the present perfect and the past simple. Each of these tenses is used for specific purposes. The present simple is used to state general facts as in the following examples:

- *Today, just over half of NIH-funded clinical-research participants* ***are*** *women.* (Clayton & Collins, 2014, p. 282)

- *While promising, GFP-based methods* ***rely*** *on cellular transfection that* ***proves*** *to be difficult to achieve in certain primary cell types*. (Kucsko et al. 2013, p. 55)

The present perfect tense is preferred to describe actions that happened in the past (such as methods) but are still relevant to the present like in the following sentences:

- *Fluorescent polymers and green fluorescent proteins (GFPs)* ***have*** *recently* ***been used*** *for temperature mapping within a living cell.* (Kucsko et al. 2013, p. 55)

- *Certain rigorous studies evaluating the effects of sex differences* ***have been*** *effective in bridging the divide between animal and human work.* (Clayton & Collins, 2014, p. 282)

The past simple tense is usually selected when discussing previous studies or past actions that appear often in the Methods. For instance:

- *Earlier this year, a study* ***demonstrated*** *that mice with XY chromosomes in the central nervous system* ***had*** *greater neurodegeneration than* ***did*** *those with XX chromosomes.* (Kucsko et al. 2013, p. 55)

- *More than two decades ago, the US National Institutes of Health (NIH)* ***established*** *the Office of Research on Women's Health (ORWH).* (Clayton & Collins, 2014, p. 282)

Furthermore, the three main simple tenses can be used in the Introduction of a scientific article because they serve its major goals and they correspond to the three main parts of it: citing previous work, stating new conclusions and suggesting further applications for the work. As stated in the University of Leicester guide (2009), "an appropriate use of past, present and future tenses can contribute to a clear and unambiguous writing style" (p. 24). In other words, the use of different tenses is crucial and can help to "clarify what happened or what you did in the past (past tense), what you conclude (present tense) and what will be an issue for the future (future tense)" (University of Leicester, 2009, p. 24).

3.3.3.3.3. Tenses in the Methods Section

The role of the Method section is stating what was done during the research. The tense that fits such a role is the past simple, sometimes in the passive voice. However, the past simple is not exclusively dominant in the Methods section. The present simple tense is preferred when figures and tables are used in this section in order to keep validity of information they contain. (Swales & Feak, 2004)

The nature of scientific writing and the information it displays require the use of the past simple tense especially when describing the methods, experiments and/or observations that took place earlier. For example, expressions like "*The data were analysed… The solution was decanted… The temperature was recorded*" frequently occur in this section. (University of Leicester, 2009)

Similarly, Nolan (2016) states that the dominant tense in the Methods section is the past simple tense. Sometimes, the past perfect and past continuous tenses are required. The past simple is used in order to describe the materials and methods that were employed during the study. For example:

> - *Bacterial genomic DNA **was isolated** from mice faces, **amplified** for V1–V4 hypervariable regions of the 16S RNA gene, and **used** for pyrosequencing analysis*. (Yoshimoto et al. 2013, p. 100)

The past perfect, however, is preferred when describing an action that occurred before another action, as in the following sentences:

> - *As a substrate, we used degenerately doped silicon onto which a 270-nm-thick layer of SiO2 **had been grown***. (Lopez-Sanchez et al. 2013, p. 499)

> - *Once the temperature set in the thermostat **had been reached**, the system was allowed to equilibrate for 30 min*. (Nielsen et al. 2013, p. 86)

On the other hand, the past continuous is used when stating an 'ongoing' action that took place in the past. For example:

> - *Participants were asked to recall what they had been told about post-HCT QOL as they **were preparing for** transplant*. (Jim et al. 2014, p. 300)

- *Patients with relapsed and/or refractory MM whose disease **was progressing** after two or more prior lines of therapy were eligible to participate*. (Badros et al. 2013, p. 1710)

Additionally, the past perfect can be used in the Methods section to refer to prior research stages of the experiment as illustrated in the sentence below:

- *the seeds **had been exposed** to ultraviolet radiation for 4 hours before sowing*. (Lopez-Sanchez et al. 2013, p. 499)

However, the future tense is not appropriate or it is out of use in this section because “the materials and methods section is an account of your actions and not your intentions” (Joshi, 2014).

3.3.3.3.4. Tenses in the Results Section

Methods and Results sections together shape the central part of a research article. They are the main sections because they describe what was done and what was found during the research. Therefore, the past simple is “the natural choice” in both sections (Joshi, 2014). Similar to the Methods section, the past simple is not the only tense used; as Nolan (2016) puts it, “sometimes the present tense is required”. The past simple is used when describing the findings of an experiment because they occurred before writing the paper. The following sentence illustrates the use of the past simple:

- *Analysis of the identified gene set **revealed** the induction of a broad-spectrum antipathogen response*. (Ariotti et al. 2014, p. 103)

The present simple, however, is used in order to describe results that can be stated as a general fact like in the sentence below:

- *Consistent with the former finding, challenge with the flagellin 51 MAMP peptide, flg22 (ref. 10), or the necrotroph Botrytis cinerea 52 11 **suppresses** photosynthesis-related transcripts*. (De Torres Zabala et al. 2015, p. 15)

The present simple is required in the legends of figures and diagrams in the Results section as well (Swales & Feak, 2004); for example:

- *Table 1 below* ***shows*** *the stream flows calculated for each stream using Equation 1*. (“*Using tenses in scientific writing*”, 2012)

3.3.3.3.5. Tenses in the Discussion Section

According to Nolan (2016), the discussion section requires the same mixture of tenses as in the Introduction. This is due to the fact that in the Discussion, the researchers mention what they have done (summary of Methods), what they found (summary of Results), what the findings mean (as Discussion) and how they can be used later (recommendations or applications of the research). For that reason, a mixture of tenses is used, each is correspondent to a particular type of information mentioned above. These tenses are respectively: present/past perfect, past simple, present simple and the future.

When it comes to discuss or explain an experiment or research, the best tense is the present simple (Swales & Feak, 2004) as in the following sentence:

- *Removal of vegetation for agricultural purposes* ***appears*** *to negatively affect the water quality of streams*. (“*Using tenses in scientific writing*”, 2012)

The past simple tense is also used in order to summarise or state the obtained results. Interpretation of results is in the present tense (Swales & Feak, 2004). The sentence below contains both cases:

- *Leaf carbon and phenolic content* ***did*** *not differ across sites, indicating that the response of secondary plant chemicals such as phenolics to water* ***is*** *complex.* (“*Using tenses in scientific writing*”, 2012)

As stated by Labaree (2009), the present simple is the most appropriate tense to state general, known facts. However, the past simple is preferred when referring to previous, specific works or studies if necessary. The future tense is required when discussing the implications of the study. This is illustrated in the sentence below:

- *Demonstrating whether forest elephants use clearings to maintain their relationships* ***will allow*** *us to understand how elephant social relationships vary across the wide range of ecological conditions occupied by both forest and savannah elephants*. (Fishlock & Lee, 2013, p. 360)

3.3.3.3.6. Tenses in the Conclusion

The Conclusion section requires a mixture of tenses; most frequently: past simple, present simple and future simple (Swales & Feak, 2004). The following sentence is taken from a conclusion of a scientific article and it includes two tenses: the past simple and the present simple.

- Although the study ***found*** evidence of tillage and irrigation within the study area, from the data collected, it ***was*** not possible to determine if the effects of agriculture upstream ***cause*** (or ***caused***) higher levels of total nitrogen downstream. Further studies ***are*** therefore necessary to determine the effects of agriculture on the health of Stringybark Creek. ("*Using tenses in scientific writing*", 2012)

Darling (2002) states that each part of the Conclusion requires a specific tense. Table 6 below summarises the tenses -in addition to some frequent expressions- in correspondence with each type of information being presented along with examples.

Table 6. Tense Use in the Conclusions and Summary Sections

Type of Information	Verb Form (tense or commonly occurring verbs)	Examples
Referring to the purpose	simple past tense	*In this study, we concentrated on showing the interdependence of the variables involved*
Restating the findings	simple past tense	-*The main conclusion was that modifications to the model were needed.* -*We also showed that the sensor sensitivity depended very little on the sensor diameter.* -*We finally obtained a curve showing the depth of penetration as a function of time.*
Explaining the findings	present (general condition) simple past (restricted to your study)	-*Filtration produces a satisfactory result* (in general). -*Use of the web-based environment provided the greatest saving in staff time and cost to the company* (in this study)
Limiting the findings	a variety of expression is used: • the findings are restricted to... • it cannot be determined from this data • we cannot be certain... • we are unable to determine... • we acknowledge that this study is exploratory	-*Our aim was to assess the current procedures, not to develop new ones* -*Without further investigation, we are unable to determine the cause of this with any degree of certainty*
comparing findings	present tense	-*The results obtained in simulation show excellent agreement with the corresponding experimental data* -*This is in discrepancy with the earlier conclusions of Järvinen* -*This corresponds to the findings of Eklund*
Implications / Generalisations	verbs indicating tentativeness: - is possible - appears - is likely - seems - might	-*It is possible that these differences in quality will show up during prolonged use* -*It is highly likely that this could occur again*
Recommendations and Applications	common constructions: • should be + -ed • could be + -ed • would be + -ed • must be + -ed • we recommend • X is recommended • it is hoped that....X may...	-*It should be noted that the security arrangements should be tightly controlled* -*Longitudinal studies of company practices could also be set up* -*It is hoped that benchmarking may become a higher priority within the institution* -*Further study is recommended to compare results with types of plastics which were not included in this study*

Note. From Darling, (2002)

3.3.4. Phrasal Verbs

A Phrasal Verb (can also be found as *multi-word verb*) is defined in Oxford Dictionary (2011) as "a verb combined with an adverb or a preposition, or sometimes both, to give a new meaning", for example:

- *Jan **turned down** the chance to work abroad.* (verb + adverb)
- *Buying that new car has really **eaten into** my savings.* (verb + preposition)
- *I don't think I can **put up with** his behaviour much longer.* (verb + both) (p. 949)

Similarly, Cambridge Dictionary (2008) defines it as "a phrase that consists of a verb with a preposition or adverb or both, the meaning of which is different from the meaning of its separate parts:

'*Pay for*', '*work out*', and '*make up for*' are all phrasal verbs." (p. 70)

Another definition is that in Collins Dictionary (Black, 2009). In English grammar, a phrasal verb is "a phrase that consists of a verb plus an adverbial or prepositional particle, especially one the meaning of which cannot be deduced by analysis of the meaning of the constituents. '*Take in*' meaning '*deceive*' is a phrasal verb". (p. 241)

On the other hand, Busuttil (1995) believes that these definitions are not accurate; the second part of the phrasal verb should only be called *adverb* instead of *particle* which replaces both adverb and preposition, or as he calls them: "*ADPREPS*". In other words, the second part of the phrasal verb functions as an adverb whether it is originally an adverb or not (p. 57). However, some scholars prefer to call it '*particle*' including Veldi (2006) who differentiates between two types of particles which are:

- adverbial particles such as **up**, **in**, **out**, **off**, **down**, and **through**
- prepositional particles such as **at**, **for**, **to**, and **with**

Generally speaking, most writers in English face a problem with using phrasal verbs. The first issue that arises when employing phrasal verbs is ***formality***. Even though some phrasal verbs are considered informal and not accepted in academic writing, they are frequently used especially in reports such as scientific articles, laboratory reports, etc. (Fletcher, 2005). Some unaccepted phrasal verbs in academic discourse or formal writing in general are listed below. A single word can accurately replace these phrasal verbs as shown between brackets.

- *Get up* (rise or increase)
- *Put into* (contribute)
- *Looked at* (discovered)
- *Got together* (merged)
- *Accounted for* (explained)
- *Brought about* (caused)
- *Cut out* (deleted, cleaved, suited) (Enago Academy, 2016)

On the other hand, some phrasal verbs are positively formal and even preferred to single-word alternatives. They commonly occur in scientific and technical or general academic contexts. For instance:

- We **carried out** an experiment…
- This experiment **consists of** three…
- As **discussed by** Jones et al,
- These recommendations are **based on** …
- Each test was **subjected to** … (Enago Academy, 2016)

The second problem with phrasal verbs is ***meaning***. What makes phrasal verbs difficult (especially for NNS) is that the meaning of the whole expression is different from the meaning of the individual words that constitute it. For example, the phrasal verb "to carry out", which is commonly used in technical contexts, means "to execute, perform or accomplish" (an experiment, research, etc.). This meaning is completely different from the meaning of “carry” alone (which is to take something from one place to another) or “out” (which means finished or moving away). (Enago Academy, 2016)

Due to this problem, science or academic writers are advised to avoid using phrasal verbs which they are not certain about their exact meaning especially when one word can convey the same meaning. As mentioned earlier in this research, scientific writing is economic, simple and precise. Therefore, one word is better than a combination of two or three words.

However, some phrasal verbs cannot simply be replaced by a single word. For example, the phrasal verb “carry out” is better used than “do” or “execute” which are neither accurate nor precise in technical contexts. It is better to write: “*the researcher has carried out the experiment* …” than “*the researcher has done the experiment*”.

Moreover, a third problem (can be related to the previous one) is when a phrasal verb has many possible interpretations or uses. It becomes difficult for science students to figure out the correct meaning or the appropriate use in the content they are communicating. One combination may have several meanings depending on the context in which it is used. Therefore, writers should be careful using phrasal verbs as such. A good example is the phrasal verb ‘*cut out*’. Some of its meanings are as follows:

- Delete or remove (e.g., The irrelevant paragraph was ***cut out***)
- Shape by cutting (e.g., The DNA model was ***cut out*** using scissors)
- Suit or equip (e.g., She was not ***cut out*** for the task)
- Cease operating (e.g., The engine ***cut out***)
- Exclude (e.g., Group 2 had sugar ***cut out*** of their diet). (Enago Academy, 2016)

The solution for science writers is to be careful when using phrasal verbs. First, they have to ensure that the use of the phrasal verbs is appropriate and the meaning they intend to express is correct. Second, they have to look for single-word alternatives and check if they convey exactly the same meaning and if they are concise and precise. (Busuttil, 1995; Enago Academy, 2016)

What (NNS) academic writers usually are unaware of is that not every combination or sequence of a verb and adverb or preposition shapes a phrasal verb. It depends on 'the degree of idiomaticity'. In some cases, the combination is not idiomatic, i.e., the preposition (or adverb) is separated from the verb; each is used individually. Cowie and Mackin (1975) provide some examples (in Table 7) to explain the degree of idiomaticity and how the same combination differs from one sentence to another. (Cited in Busuttil, 1995)

Table 7. Degree of Idiomaticity in Phrasal Verbs

1. The machine turns on a central pivot	non idiomatic
2. Our conversation turned on what was to be done when the battle was over	more idiomatic
3. The caretaker turned on the hall lights	Idiomatic
4. Pop music turns on many young people	highly idiomatic

Note. From Cowie and Mackin, (1975. Cited in Busuttil, 1995, p. 60)

The first sentence contains a simple verb plus a preposition which do not form a phrasal verb. The verb is *turns* and *on* is a preposition in the complement "*on a central pivot*". The same combination gets more and more idiomatic in the other sentences. *Turns on* in sentence 1 is totally different from *turns on* in sentence 4. In sentence 1; it means: *run* or *make something work* whereas in sentence 4, it means: *move* or *excite.*

Another noticed problem with phrasal verbs is the choice of the appropriate particle (adverb or preposition) to be used after the verb. This problem reflects NNS writers' lack of understanding of phrasal verbs. It is also mainly due to the fact that they translate from their mother tongue (here Arabic) or from French (their second language) which is a language that lacks phrasal verbs. (Veldi, 2006)

Veldi (2006) classifies this mistake as 'semantic confusion'. Writers may fall in the mistake of wrong verb choice where a single-word verb is preferred to a phrasal verb, or correct verb but wrong chosen particle as in the following examples:

- They **fill up** (fill in) many forms.
- It is a task which must be **carried on** (carried out) using the brain.
- Sect members are told to refrain from talking to their parents and to **keep out** (keep away) from their friends.

There is a similar case where the particle is correct and the verb is not. It is also classified into the same category of mistakes. It is usually due to the issue of translating from Arabic or French as well. For instance:

- We tried to **come back to** (go back to) Los Angeles.
- Saddam Hussein had the power to **shut off** (turn off) the heat in millions of homes. (Veldi, 2006)

Conclusion

This chapter may function as a guide for science students/writers that can help them improve and proofread their writings, especially at the levels of style, lexis and syntax as it brought about a clarification of how language style in science communication is unique and distinct. It also highlighted two main aspects of language, namely vocabulary and grammar along with their particular use and occurrence in the scientific discourse.

These language features might not be the only ones that writers usually find problems with. The digging in their writings in search for errors is a convenient way to spot other problems and provide possible remedies. The next chapter explains this notion.

Chapter Four

Research Framework

Chapter Four

Research Framework

Introduction

This chapter provides a description of the research methodology employed in this study. It includes presentation of the tools used in this research. It also presents the situation design, namely the population to whom the questionnaire was administered, in addition to the lessons conducted about scientific English and the scientific article.

It, then, describes the questionnaire. It also contains a sufficient description of the lessons that were conducted with the students including the objectives of the lessons and the reactions of the students about the content being presented. There is also an adequate explanation of the investigation process, which is a two-analysis experiment: the first analysis of the first set of scientific articles and the second analysis of a second group of articles. Both analyses were conducted systematically to be able to explain the students' needs thoroughly and accurately.

4.1. Research Methodology

According to Zarah (2010), research is a "tool for building knowledge and efficient learning and a means to understand various issues". Scientific research has been applied to "bring together observations, knowledge and data to solve problems, invent solutions" (Kane, 2017) and develop new concepts and/or methods. A problem was observed with science students that concerns the English language. In the attempt to solve this problem, an idea that may later be used to help all science students in Algeria has emerged. That is why this research was carried out in order to *test* this idea "by transforming abstract theories into practical learning" (Kane, 2017).

In this study, the main purpose is to detect Algerian science students' problems with English and to find the most suitable way to solve them. The way suggested in this study is *teaching* the students in question the main features of English for Science and Technology and the scientific writing style in addition to certain language points with specific occurrence in the scientific article. For that reason, an experimental method was selected in which the suggested way -tutoring- was investigated and assessed with a case study, which is a group of PhD students of chemistry.

Case study method "enables a researcher to closely examine the data within a specific context" (Zainal, 2007, p. 1). The choice of case study method is seen appropriate in this investigation because it is specifically directed and targeted. It permits the limitation of target population as it provides complete and 'in-depth' explanations of the problem(s) being investigated. It also helps explain the process and the findings "through complete observation, reconstruction and analysis of the cases under investigation" (Tellis, 1997. Cited in Zainal, 2007, p. 1).

The objective of this study is to identify the difficulties of non-native speakers (henceforth NNS) science students with the English language and help them to overcome these difficulties. The treatment presented here has been chosen as the most suitable way to achieve the underlined objectives. It was conducted taking into consideration the fact that they need English; first, to read in order to collect information concerning their studies regarding the fact that most scientific articles, some books and other publications are written and published in English. Secondly, they need English to write so as to communicate and share their own work in an attempt to contribute to the science outcome in the world.

Moreover and in order to achieve the desired objectives, action research was chosen because it requires the researcher's involvement; in the case in hand: as an *educator* (tutor). The reason for the researcher's engagement in this study is to assist the targeted sample population to improve their action, which is, in this case, *writing*. Action research allows both the tutor (the researcher) and the participants (selected science students) to "work best on problems they have identified" (Watts, 1985, p. 118).

Among the several types of methods recommended in the research about education, the experimental method was elected because it permits control how the students are treated, as it allows to measure the impact and effectiveness of the treatment conducted: Tutoring (Moore, McCabe & Craig, 1993). In other words, the experimental method here helps identifying the students' needs and difficulties, providing a set of solutions and checking the applicability of these solutions. The experimental method can correctly test the research hypothesis because it involves *cause-and-effect* relationships.

4.2. Corpus and Participants

4.2.1. Corpus

In the present work, in addition to a case-study method, a corpus is required, which is the written production of the target population. However, the main study was conducted around the performance of the chosen case study not the corpus collected even though there was an analysis to this corpus and that analysis played a key role in the entire investigation.

Hence, in order to analyse patterns of language use (mainly errors) in particular units (scientific articles), the collected corpus was written using the Word programme and sent through e-mails; others were shared through Google Drive. Following in-depth investigations of the errors committed by science students when writing in English can reveal the reasons behind these errors and may allow finding out convenient solutions to their problems and difficulties with the scientific English and writing scientific articles in English.

The scientific papers were between 16 to 22 pages length (not counting tables and figures added in the appendices). The examination focused on: grammar, choice of words, sentence structure, phrasal verbs and tenses.

4.2.2. Subjects' Sampling and Population

The target population of the present research is doctorate students of nature sciences in Algeria. However, it is not achievable to conduct an investigation on such a large population for two main reasons. The first is the fact that there are over sixty universities in Algeria; most of which comprise science departments. The second reason is there are several -nature- sciences taught in the Algerian universities that are covered by this population like physics, chemistry, Earth science, biology, etc. and the number of doctorate students is expected to be extremely large. Thus, the students belonging to these fields are not possible to be enumerated exactly or even contacted all.

Therefore, the sample drawn from this target population is doctorate (PhD) chemistry students from the University of Annaba. From this parent population, a sample of thirteen (13) students was selected. All participants selected for this study started their PhD in either of the academic years: 2012-2013 or 2013-2014.

The number of the selected sample of students (13) might seem to be a small number but the fact that the target population was PhD students made it difficult to find more -willing to collaborate and sharing similar interests- students. The procedure itself (analysing -at least two- scientific articles written by the students; the conduced lessons) was not possible to be conducted with a larger sample for several reasons including time, availability and sharing-paper issue (to be detailed further). This number, then, is (hoping) a sufficient number of students who share the same field of study on the one side, and the same problems with the English language on the other. Even though, the findings of this research might not be generalised on all science students in Algeria since it is not known how English is taught in other faculties, the chosen sample had confirmed that most of their colleagues have almost the same difficulties. On that count, this work may find a rather larger eco among science students in Algeria.

To summarise, the chosen sample is a group of 13 PhD students of chemistry; Classic System (Doctorat es. Science) from the University of Annaba. These students have had their university studies in French and at this stage; they found themselves in need to write in English.

4.3. The Pilot Study

A pilot study allows to ask whether a particular work can be carried out, and whether the researchers should proceed with it, and if so, how (In, 2017, p. 601). According to Cadete (2017), pilot studies are “small-scale, preliminary studies which aim to investigate whether crucial components of a main study (…) will be feasible”. In this research, a pilot study was conducted in order to check some essential points concerning the research tools, the suggested method and the appropriate population for this study before proceeding with the designed investigation. The pilot study consisted of two questionnaires; the first was addressed to teachers of English in some science departments. The second was handed to a group of PhD students of different scientific domains. Both teachers and students belong to the University of Constantine 1.

The questionnaires were sent to teachers and students via emails. They were informed of the purpose of the study and the objectives of the questionnaires. Both teachers and students were interested especially that the discussed topic aimed to enhance the way English is taught in the departments where they belong.

4.3.1. Aims of the Pilot Questionnaires

The pilot questionnaires were designed to check the feasibility of the main study. In order to have a clear vision on the tools to be used in the study, mainly the suitability of the main questionnaire and the practicality of the suggested solution (tutoring); the pilot study aimed to:

- provide an overall idea of the experiment and allow to see whether to add, drop or change any part of it;
- improve the main questionnaire by adding essential questions or modifying unclear ones;
- decide on the sample nature and size; i.e., how many students and what field they study; and,
- test students' reaction to the subject under investigation. (Are they familiar with EST? Have they heard of it? Is the investigated subject important in their training? Are they interested in this work?)

4.3.2. Teachers Pilot Questionnaire

This questionnaire (cf. appendix 1.) was addressed to eight (8) teachers of English in several departments of sciences, the departments to which the students (responders to the second pilot questionnaire) belong. It aimed at understanding how English is taught in such departments since it is not considered a fundamental module. Another problem appeared was the fact that the target population (Doctorate science students) do not study English at this stage (they do not study at university except for doing research). However, it was necessary to know how they had English in previous stages of their university studies (BA and MA). Teachers can precisely state the content of the English lessons in order to see whether the students had a training to write in English and particularly to write scientific articles.

4.3.2.1. Describing the Questionnaire

The pilot questionnaire consisted of 15 questions, between yes/no questions, which are used to gain precise statistics about certain details, and open questions, which need individual answers and explanations to recognise the position of English from the point of view of teachers. The questionnaire was mainly about the position of English in the departments of sciences: How it is taught, how much time is devoted for it, what content is being taught in the lessons and whether students did benefit from them as far as their needs in this stage (PhD) are concerned. It was also about whether science students are interested in English and what difficulties they have according to their teachers.

The first group of questions (Questions 1, 2, 3, 4 and 5) were about the status of the questioned teachers as related to their studies and to their work in these departments. The second set of questions (Questions 6, 7, 8, 9 and 10) aimed to know the content of the lessons, the materials used and the relevance of the topics being presented. After that, they were asked about the students' interest, motivation and level (Questions 11, 12, 13 and 14). Finally, they were asked about what they thought would be convenient and more interesting for EST learners -regarding their experience with this kind of learners- and what could benefit them (Question 15).

4.3.2.2. Analysing the Questionnaire

Q.01. What did you study at university?

Most of the questioned teachers have studied English. Two of them have studied translation.

Q.02. Are you a vacant or certified teacher?

All the questioned teachers were vacant.

Q.03. How many years have you been teaching in the chemistry/physics/engineering department?

Three of the questioned teachers said that they have started teaching in this department only this year. Four of them said they have been teaching there for two years. Only one said she has taught for three years but in different science departments.

Q.04. Do you teach only in this department?

Most of the teachers teach only in these departments except two of them who teach also in the commerce department.

Q.05. What level(s) do you teach?

The questioned teachers have under-graduation students (1L, 2L, and 3L). Only two teachers have master one classes.

Q.06. How many sessions/hours per week is devoted to English for each class?

All of them said that there is only one session of English per week, which lasts one hour, and a half.

Q.07. What do you teach exactly?

The content of the lessons provided by the questioned teachers was mainly: Terminology (words related to their field of study), English texts with comprehension questions (similar to the BAC exam) or translation of words and sentences from and into French or Arabic.

Q.08. Who decides the content of the programme?

For most of the teachers, the content is chosen and prepared by them. Only few teachers said that they have received a designed programme from the head of the department when they started teaching.

Q.09. What sources/materials do you rely on to prepare the lessons?

For most of the time, the Internet was the best source of information especially that the teachers were not familiar with the study subject of their students. They have sometimes used dictionaries to provide words and their definitions or translation.

Q.10. Are the topics you teach up to date?

According to the questioned teachers, the content focused mainly on scientific vocabulary. Those who used texts related to the students' field of study said that they could not tell if the topics were recent, up-to-date or not. They have said that they looked for texts they could understand themselves and could help them with their teaching.

Q.11. Are the students you teach interested in the content you provide?

The answers to this question differ from one teacher to another. Some of them considered their students interested especially when the topic was scientific terminology. Some of the students did not show interest because of their low level in English, which did not allow them to understand what was presented. Some of the questioned teachers noted that the status of English (it was an extra module, did not affect their marks, was not related to their studies' objectives, etc.) was the main reason behind the lack of interest of the students.

Q.12. Do students attend your sessions regularly?

There were two diverse answers to this question. The first was that the majority of the students attended the English class regularly. The second was that only few of them attended while the rest of them showed up only in the exams.

Q.13. Do you face difficulties with students' level?

The questioned teachers said that most of the students have low level in English. A few them only had higher level between average and good. They have also mentioned that the low level of the students was what made them teach vocabulary only and did not deal with other language aspects.

Q.14. At what points exactly do you find difficulties?

The low level of the students and their lack of motivation affected their comprehensibility. In lessons such as scientific terminology and translation of words, the problem could be solved with explanation of the words in their first language. However, in dealing with texts and comprehension questions, there was difficulties understanding the texts or even understanding the instructions and the comprehension questions.

Q.15. What can be more useful or interesting for these students?

According to the questioned teachers, science students need more than mere translation of words in their field of study. They have provided the following suggestion to enhance the content of the English lessons for such students.

- First, science students have to understand that English is very important in their studies. They have to be informed of ESP/EST especially for those who want to have further studies.
- Second, it would be more useful if they had preliminary level and went through basic concepts such as grammar.
- Third, it would be more useful if teachers knew these students' needs from English.
- Fourth, the content of the lessons should be enriched with reading texts or articles, videos -in English- related to their specialty, writing or at least summarising the text they read and presenting ideas and information related to their studies in class (orally).

4.3.2.3. Interpreting the Questionnaire

The results obtained from this questionnaire revealed that English was only an extra module; the time devoted was not sufficient. The content did not meet students' needs especially for the post-graduation stage. Some of the teachers taught them *terminology*, which is words related to their field of study, translated into either Arabic or French. Some others taught text comprehension similar to the exam type in the secondary school. However, the content (theme) was related to their study field. None of the teachers explained the existence or importance of ESP or EST to the students; which could have been useful (as reported by the students).

Most students were not interested in the English class because they considered it as an unnecessary subject regarding the importance of the other subjects they were studying and they had to focus on. Their lack of interest can also be justified by their low level, which -for some- did not allow them to understand even individual words as stated by their teachers.

The questionnaire revealed that the best way to overcome this lack of interest of science students in the English language is to show them its significance and role in the communication of science; especially for those who want to proceed in further steps in their studies (PhD). In addition to that, it would be more useful if teachers knew these students' needs from English. Based on these two major points, the English courses for science students could be improved and meet students' goals, desires and aspirations.

4.3.3. The Students Pilot Questionnaire

The idea of this research is to examine science students' performance when writing scientific articles in English. Only PhD candidates are concerned with this genre of academic papers (in addition to scientists working in laboratories and research centres but are not of interest in this study). Therefore, this questionnaire is handed to ten (10) PhD -randomly selected- students of different sciences: physics, biology, chemistry, etc. in order first, to see if this work is feasible with such a large and varied population; and second, to identify their needs and their weaknesses in English.

4.3.3.1. Describing the Questionnaire

The pilot questionnaire (cf. appendix 1.1.) which was addressed to the PhD students consisted of -more than- thirteen questions (Yes/No questions, MCQ and Wh-questions). They were mainly about the status of English in the departments of sciences where the questioned students belong. They were also about whether English courses helped them in their post-graduation studies. Some questions were about the students' level in English while others were about their needs from English and its use in their studies. As PhD candidates, their main work was to read and write articles and theses. Therefore, they were asked about the language they use to write and/or read in their field of study. Finally, the students were asked to suggest any improvements to the English courses at university that can benefit science students in the future. The researcher was present to provide immediate answers to any raised questions and to observe the students' reactions and write down their comments.

4.3.3.2. Analysing the Questionnaire

Q.01. In what language did you have your studies at university?

All the questioned students said that they had most of their studies in French. Some modules were in Arabic or a mixture of Arabic and French.

Q.02. Did you study English at university?

All the students replied that had studied English as a module during their BA or MA with only one session per week. The students thought that one session was not enough to learn English.

- To what extent the English courses helped you enhance your level in English?

Most of the students (70%) claimed that the English lessons did not improve their level in English. The rest 30% thought that it might have slightly helped them.

- What lessons did you have in these English courses?

All the students agreed that the most frequent point in the English lessons was vocabulary, whether technical words in their field of study or translated into French or Arabic. Two of the students added another component which was grammar.

Q.03. What do you think your level in English is?

60% of the students believed that their level was low. 20% thought their level was average and 20% thought their level was high.

- How would you justify your level?

The students with low level mentioned that studying and using French in almost all their studies is the major reason behind their low level. The others who have an average level said that they like English and understand it. The rest with high level mentioned that they have learned the language in a private school and worked on their level through films, books, social media and YouTube.

Q.04. Do you think your current level in English allows you to write / read English documents (articles)?

The answers to this question are related to how the students thought their level is in previous question. The students who thought their level is high in English (20%) believed they could write and read articles in English while the others thought the opposite (80%).

Q.05. As a PhD student:

- In which language do you write your thesis?

- In what language do you have to write your article(s)?

All the questioned students declared that they were writing their theses in French. However, all of them were writing their articles in English.

- Why?

The students argued that this difference in the language of the thesis and the article was due to the fact that the journals they had to publish in were international journals and usually published in English, and thus, they had to write their articles in English.

- Have you written -journal- articles up to now?

Six of the students have started writing articles.

- If yes:

  - In what format?

The format of the article depended on the requirements of the target journals (instructions for authors). Some of them mentioned the IMRD format which was suggested by their supervisor.

  - What difficulties did you encounter with when writing your article(s)?

All the students answered this question including those who have not yet written articles. They mentioned that the difficulties they usually faced were finding the journals they could publish in and sometimes how to start writing. Those who have tried writing found difficulties with:

- the format;
- the titles and subtitles;
- the language (English);
- writing the introduction and the literature cited; and,
- discussing the results.

Q.06. In what language do you usually find the documents you need in your studies?

The most frequent language of scientific documents -such as books and articles- was English. French and German came second with a percentage of 20%.

- Can you explain why the documents you need in your studies are found in this particular language(s)?

Most documents especially international articles were in English. Theses especially in Algeria were found in French. Some important documents especially books were in German.

Q.07. Would you like to learn?

All the students preferred to study English for Science and Technology saying that learning "specialized English" may help them understand the documents they read and write their articles.

Q.08. Based on your experience, the English courses for -university- science students should cover: Vocabulary / Terminology - Grammar Rules **-** Written Expression **-** Reading Comprehension.

According to the questioned students, all these aspects must be presented in the English course at university. They added that EST, how to write journal articles and citation style (such as APA)

Q.09. According to your needs, order the following skills from most necessary (1) to least necessary (4). (Listening – Speaking – Reading – Writing)

Reading and writing came first in the choice of the students. Speaking came second and listening came last. They have justified this order stating that they needed English mostly to write their articles and to read and understand previously published work in their field of interest. Listening and speaking are also important skills but reading and writing are more important. These two skills are important to participate in study days or conferences in English. For some of them, listening is also important to learn about our field of study from YouTube and online courses.

Q.10. If you do not understand what you read when you are reading a document in English, what do you do?

The most frequently used techniques by the students were using the internet (35%) and translating the difficult words and phrases (30%). Some of them used dictionaries (20%) or look for the same document in French and read it (5%).

Q.11. How do you overcome your deficiency in writing in English?

The techniques used by these students to overcome their deficiency in writing in English were mostly imitating similar papers (style, titles, layout, etc.) (30%) or simply writing and submitting their papers and waiting for the correction of the supervisor or the journal experts (25%). Some of them asked for help from English speakers (20%). They have also mentioned that they write in French and then translate them into English (15%) or use dictionaries to explain or translate important words (10%).

Q12. Do you think the techniques you have selected or mentioned in the previous questions (10 and 11) are efficient?

The majority of the students answered that these techniques were not quite efficient and did not provide the necessary help, neither in reading nor with writing. They argued that none of these techniques was efficient because they always met difficulties (especially those with low level). In addition, they had to constantly write (more than one article) which urged them to learn how to write well.

Q13. As science students: what do you suggest to improve the English courses at university and make them meet your needs?

The questioned students have understood their need for English when they started the doctorate phase of their studies. That is why they recommended the English course presented for science students (even in earlier stages) to include:

- more about writing (articles in particular);
- reading comprehension;
- English for science; and,
- words that are similar to French in writing but different in meaning.

4.3.3.3. Interpreting the Questionnaire

All the questioned students had their university studies (BA and MA) in French. Some of them said that they had studied some modules in Arabic. All of them studied English but only as an extra module for one session per week, which, as they thought it, was not enough for them. They also declared that these courses did not help them improve their level in English. The content of these courses was mainly vocabulary or words translated from English into either Arabic or French. Moreover, most of the students believed that their level in English is not high (60% low - 20% average). Those with low level justified saying that they used to use French in almost everything concerning study or work and that English appeared only recently (after starting post-graduation phase). Because of their level, they supposed they could neither write nor read in English without help.

The second part of the questionnaire was about the language they deal with as doctorate candidates. For most of them, French is the language they use to write their theses. However, they use English to write their articles (journal, to-be-published articles) because most if not all journals oblige them to use English and in order for them to reach international journals as well. Their level in English and unawareness of EST were the main reasons behind their writing problems. Concerning the documents they read in their field of study, English is dominant (international articles); French (theses in Algeria) and German (for chemistry students: some books and articles) come second.

The students preferred to study EST (English for Science and Technology) rather than General English because they believed it would help them understand what they read and know what to communicate and how to communicate their findings in English. That is why they thought that the English courses at university should cover EST, writing journal articles and citation styles in addition to vocabulary, grammar and reading.

Concerning the skills: Reading, Writing, Listening, and Speaking, students argued that the most important one is writing, as they need to write their articles. Reading is as important (including understanding and analysing) because the big majority of the papers they deal with during their studies are published in English. Listening and speaking are also important skills since they help students improve their level in English, gain knowledge about their study subjects (through listening to or watching videos) and participate in study days or conferences in English.

It is imperative to mention that these science students had adopted some techniques or methods in an attempt to overcome their weaknesses when reading and writing in English. Translating into Arabic or French, using dictionaries or the Internet, and asking for help from teachers or supervisors are examples of these techniques. However, they claimed that these techniques are neither always sufficient nor effective to solve all their problems and difficulties vis-à-vis writing and reading in English. Therefore, they suggested to improve the English courses by covering EST, reading comprehension, writing articles and “words that are similar to French in writing but different in meaning”; i.e., false friends (one of their answers is quoted here).

4.3.4. Results of the Pilot Study

The pilot study was designed to help improving, visioning and orienting the designed investigation on different levels: the type of population to be targeted, the main questionnaire to the students and the focal points to be presented in the study based on students’ needs and weaknesses. The analysis of the questionnaire resulted in the following notes:

(1) The target population did not study English (properly and applicably), and when they did, they were not aware of its importance and that they would have needed it at this stage.

(2) The sample of the target population cannot be chosen from different sciences (the sample students had better study the same branch) due to many reasons including the types of texts needed, content, vocabulary, explanation, examples, etc. In addition, only PhD students are suitable for this study because they are the students who are expected to write scientific articles.

(3) The main questionnaire of the study should contain questions about the *writing* and *reading* skills that the target students need the most during their training as PhD students. Reading is suggested here as a related skill and due to its usefulness in improving the writing skill (and not as a separate skill or one of the students’ needs).

(4) The students could have benefited from the presentation and explanation of ESP/EST for it may help them “know what to learn” and “where to look” instead of General English courses which are vague and too general; and thus, difficult. Sometimes,

it was misleading for the students to learn general English especially when it comes to words (for example, the concept of semi-technical words shown in earlier parts of this work).

4.4. The Main Study

The main study involves a systematic procedure, which consists of four major steps. These steps and their objectives are summarised as follows:

(1) The Main Questionnaire: to obtain quick information about the science students' problems and difficulties with the English language and with writing scientific articles.

(2) The First Analysis (Analysis One): to the first set of scientific articles in order to get deeper insights of their difficulties and detect their errors. An error analysis approach is applied in this stage.

(3) Tutoring: presenting lessons about the main points in which students find problems and have weaknesses in an attempt to remedy them.

(4) The Second Analysis (Analysis Two): to a *new* set of scientific articles written by the same students after attending the lessons in order to check their response to the short training provided through stage three above.

4.4.1. The Main Questionnaire

The questionnaire proved to be a quick data-gathering tool (Cohen, Manion & Morrison, 2000). That is why it has been chosen in the current research to be the tool of investigation and collection of required data. Based on the results of the main questionnaire, the upcoming stages of the study are directed and designed.

4.4.1.1. Aims of the Questionnaire

The aim of the main questionnaire is to extract a sufficient amount of data about science students' needs from the English language in relation to the writing skill in particular. The questionnaire was designed to gain information about the informants' needs and interests from English. It also intended to have a clear image on how English is/was taught to science students at the university. Beside the students' needs and interests, the main questionnaire sought out their problems with English and with writing in particular, and looked into the origins of these problems. In addition, it inspected the students' ability to write peculiarly scientific articles in English taking into consideration both shape and language features.

4.4.1.2. Describing the Main Questionnaire

The main questionnaire was addressed to and administered with the 13 PhD chemistry students and consisted of 30 questions (cf. appendix 2.). the questions were categorised into three sections to facilitate directing and targeting the goals and needs from the questionnaire. The questions aimed to identify the problems and difficulties that science students face with English and, particularly, with writing scientific articles in English. In addition to that, the questions aimed to recognise the main reasons behind these problems in order to provide the most convenient assistance possible.

The questions were easy and simple in order to facilitate understanding and answering, especially that the sample students' level in English was (expectedly) below average. In addition to that, there were only 30 questions so that the students do not lose motivation to complete the questionnaire. (Fowler, 1995)

The questions were of several types: Yes/No questions, MCQ questions and open questions. This variety of questions is important since it gives the students the opportunity to state the perception of their own experience. (Fowler, 1995; Cohen, Manion & Morrison, 2000)

The questionnaire was divided into three parts. The first part was devoted to recognise the status of the English language in science departments in the Algerian university. The second one helped identifying the level of the students in question in addition to the difficulties and problems they face when writing in English. The third narrowed the interest into writing scientific articles in particular and helped to check the students' aptitude and capacity to writing in a special format following the scientific style with specific characteristics.

4.4.1.2.1. Part One: The Status of English in the Department of Chemistry (Q1-Q6)

This part consisted of six (6) questions including, some of which required explanation and/or specification.

The first question aimed to recognise in what language the students have had their university education. It was important to know that because it provided clear insight on the coming procedures. The three languages that might be used in the higher educational system in Algeria are: Arabic (mother tongue), French (second language) and/or possibly English (foreign language).

It is also imperative in this study to know if these students had studied English at university (in the programme or as a subject) and if they had, how they had it. The focus on English is due mainly to the fact that in the training of science students (in Algeria and apparently in the whole world), it is significant to learn and use English in their studies, especially in post-graduation phase as well as in their career.

After confirming that the sample students had studied English during their university studies, knowing the content of the English sessions plays a significant role in this investigation. It is essential to know whether science students had received what they needed from English (what would be useful in post-graduation stage; most specifically writing scientific articles) in those sessions for a two-fold purpose: (1) to confirm whether there were gaps in the learning of English at university for such learners as a potential source of their problems; and (2) to decide on the training offered as part of this study.

If students had known that English would play an important role in the fulfilment of their higher studies, they would have paid more attention and showed a bigger interest in the courses of English they had in earlier stages. Therefore, the last question in this part aimed at showing the importance of the recognition of learners' needs not only by the educator but by the learners themselves.

4.4.1.2.2. Part Two: The Students' Level, Interests and Difficulties in English (Q7-Q20)

The second part of the main questionnaire consisted of 14 questions, intended to have an overview on the informants' level and identify their real interests and difficulties. It should be mentioned here that the students' needs do not concern writing only but reading as well (explained in previous chapters of this work). Therefore, in this part, the questions focused on both writing and reading; writing is the major interest of the study and the students' main concern, and reading as a helping factor in enhancing writing since both skills proved to have such a relationship.

The first two questions (Q7-Q8) intended to help the informants themselves think of and state their own level in English and what they used to do so as to improve their level taking into consideration their urgent necessity to using English. The next question (Q9) aimed to check whether the informants were aware of their needs from the English language. In the next questions (Q10-Q19), the emphasis shifted to reading and writing in an attempt to understand their problems with these two significant skills and see how they react to their difficulties. In their studies as PhD candidates, students need to read. Their weaknesses in reading may affect their ability to understand, analyse and write as well.

Information obtained from this part of the questionnaire helped in classifying the students and planning the content and presentation of a further step of the treatment (the lessons).

The philosopher Seneca said, "If one does not know to which port one is sailing, no wind is favourable" (Philosiblog, 2011). When one knows where s/he is going, s/he can easily reach her/his goal. In an attempt to provide the most convenient solution and -later- recommendations for course designers of English in science departments, the students can best suggest the content of the courses if they are aware of their needs. Stating the objectives of the course and the usefulness of its components is imperative in the learning process as well. Therefore, the last question in this part (Q20) required the students to propose what can be convenient for the content of the English lessons as far as their needs are concerned.

4.4.1.2.3. Part Three: The Scientific Article (Q21-Q30)

The scientific article is the heart of this study. For that reason, this part of the questionnaire was devoted to this type of papers and science students' reaction about it.

It is significant to first recognise how the students think of the scientific article and how they state its importance in relation to their studies. In their doctorate stage, chemistry students are expected to do a bunch of essential activities such as reading about their area of interest, carrying out experiments and writing laboratory reports and theses. Writing scientific articles is as important as the other activities because it is their gate to share their findings. That is why it was expected that they have got a training on writing articles. Therefore, the students were asked whether they have written articles before and in which language, and if they were prepared to write or got any kind of assistance when writing (Q21-Q24).

Students were asked about the format of the scientific article and its importance regarding the fact that mastering the format is a crucial element in writing them. One of the known layouts of the scientific article is "the IMRaD format". They were also asked about the order of writing the sections of the article, which is a fundamental detail in the process of writing articles because the content of some parts is determined by the other ones. (Q25-Q27).

After the recognition of the students' difficulties with reading and writing, the next question (Q28) sought at going further with the students' problems with writing scientific articles. No choices were provided for this question because it would be better if they stated these difficulties and problems as they recognised them.

The next question (Q29) intended to see if students were aware of the importance of the language (correct language) in writing and publishing (the main aim) scientific articles. This step is significant in building what is coming from the treatment.

The last question (Q30) was about students' suggestions and ideas for what they think the English course should contain to suit their needs based on what was referred to so far in the main questionnaire. This question may provide a basis on which the lessons in the current treatment could be built.

4.4.2. The First Analysis of the First Set of Scientific Articles

4.4.2.1. Aim of the First Analysis

Analysing students' performance in writing scientific articles is similar to Corder's (1981). It is "a procedure used by both researchers and teachers which involves collecting samples of learner language, identifying the errors in the sample, describing these errors, classifying them according to their nature and causes, and evaluating their seriousness" (Cited in Heydari & Bagheri, 2012, pp. 1583-4). In the case of this study, the students' errors will be detected, corrected, described and then classified according to their type and frequency.

The aim of Error Analysis is to recognise "what the learner knows and does not know" in matter of language use (Corder, 1974, p. 170). The purpose is not only to show that the learner has made errors but to supply him with the right sort of information or data to form a more adequate concept of a rule in the target language" (Corder, 1974, p. 170). In fact, identifying the learners' errors is crucial not only to the teacher/researcher to assess in which area the learners have weaknesses and need extra strengthening, but it is also important for the learners to correct their performance in order to learn from such errors and avoid them in the future.

The main aim of this analysis, then, is gaining a wider vision on the students' problems with writing scientific articles, and going deep with their weaknesses concerning the scientific writing style. That is why the collected articles were scanned accurately and examined attentively, looking for language problems starting from words and word choice to sentence structure and transition between ideas. After that, all the results of the analysis were brought together in order to study the type and frequency of those problems. Studying the frequency of errors allowed looking into the reasons behind them.

The First Analysis was accompanied with tiny discussions or simple inquiries about the use of some aspects over others. These inquiries shed some light on few possible reasons behind their observed weaknesses and the insufficient awareness of these problems.

4.4.2.2. Describing the First Analysis

Besides the questionnaire, which provided a generic view of the students' problems and difficulties, a set of scientific articles (13SA) written by the sample students were analysed to detect their errors and spot their weaknesses. This phase was not easy to conduct for many reasons, one of which is that students refused to share their articles due to the fact that what was required -then- was a group of articles that they had written for the first time and they had not had them corrected or submitted yet; i.e., drafts (this detail is very essential). In the beginning, the students refused to share their articles for fear of losing their credibility; plagiarism. After the researcher reassured them, they finally accepted with the condition not to share them in any form or at any circumstances. For that reason, they have shared (some) articles in which the main results were actually missing. In bearing the students' accepted condition, the analysed articles are not shared in this thesis.

This step of the main study named *The First Analysis* was time consuming because the content was difficult even though the main interest was in the language only. In some points, it was difficult to decide whether to consider an utterance erroneous or not because the intended meaning was ambiguous or unclear. As an instance of that, in some sentences, it was difficult to distinguish between the subject and the object as the verb was misplaced. In an attempt to overcome such an obstacle, the students were asked several times: "*What do you mean here*?" in order to get a correct interpretation of certain utterances. As Corder (1981) suggests, "to identify the presence and nature of an error, an interpretation of the learner's utterance is necessary" (p. 56). This question was raised few times when it was really necessary to understand if a given expression was done by mistake or due to a lack of knowledge. Thus, such an interpretation might reveal the precise difference between 'what a leaner wants to say' and 'what a learner has said'. Therefore, the teacher or researcher investigating errors has to ensure if a sentence is erroneous and "his assertion should rely on correct interpretation of the learner's intentions" (Corder, 1981, pp. 56-57). This step is called *authoritative* interpretation (Corder, 1981, p. 37). In case it was not possible to ask them each time and for those who just sent their articles and were not available for consultation, "*an interpretation of his utterance on the basis of its form and its linguistic and situational context*" could solve the problem. (Corder, 1981, p. 38. emphasis original)

It is worthy to note that "*superficial well-formedness alone is not a guarantee of freedom from error*"; i.e., a sentence might appear to be correct but, de facto, it does not express the students' actual intention. Therefore, a careful interpretation is required on the basis of several factors such as the overall context, the students' level, the part or section of the paper, etc. (Corder, 1981, p. 41)

The notable aspect, which permitted this research to be conducted in the designed method, was the fact that these students were supposed to write many articles not only one. In effect, to carry out the investigation was to analyse NEW scientific articles written by the same students.

4.4.2.3. Procedure of the First Analysis

4.4.2.3.1. Error Analysis: An Overview

During the 1960s and 1970s, many researches (Adjemian, 1976; Corder, 1967, 1974; Nemser, 1971; Selinker, 1972) have drawn the attention to the language produced by second/foreign language learners. These researches indicated that this production is 'systematic' and that their errors are not randomly made; instead, they are "evidence of rule-governed behaviour" (Khansir, 2012, p. 27). As Corder (1981) puts it, learners' errors "provide evidence of the system of the language that he is using (i.e., has learnt) at a particular point in the course (and it must be repeated that he is using some system, although it is not yet the right system)" (p. 10). Proceeding from this view of the importance gained by the study of language learners' errors, the field of Error Analysis has come into emergence within applied linguistics as a useful process in teaching a language. (Corder, 1967, 1974, 1981).

Error Analysis (hereinafter EA) is an approach within linguistics which investigates errors made by language learners in order to explain and trace their origins in an attempt to understand how learners learn a second and/or a foreign language. EA emerged as a response to the need to study the learner language; i.e., the language produced by the learner in the case of second and foreign languages. (Corder, 1967, 1981; Richards, 1984)

The importance of the study of learners' errors lies in the opportunity it offers "to draw certain conclusions about the strategies adopted by the learner in the process of learning" (Corder, 1981, p.35). Recognising these strategies would help teachers and course designers create new teaching methods and/or improve existing techniques. For that reason, Strevens (1969) hypothesises that "errors should not be viewed as problems to be overcome, but rather as normal and inevitable features indicating the strategies that learners use" (Cited in Richards, 1984, p. 4). Giving this, EA is not a simple study of the errors made by language learners, it is however "a part of the investigation of the process of language learning" (Corder, 1974, p. 125). It proves that second/foreign language learning employs similar methods used in first language acquisition. In other words, EA provides "a picture of the linguistic development of a learner" and so, it proves the occurrence of the learning process. (Corder, 1974, p. 125)

EA came as a complementary approach to Contrastive Analysis (hereinafter CA) which studies and compares systems of two languages in order to predict areas of problems and errors; EA in contrast, studies the errors deeply (explain, evaluate and interpret) in order to trace the origins of the errors and seek remedy to them. However, CA focused on errors of language learners, which were due only to interference or transfer of mother tongue; whilst EA found that not all errors are ascribed to interference of mother tongue and that there are numerous errors related to the learners' generated ways of learning a second/foreign language (such as overgeneralising, developing, imitating, etc.). (Corder, 1981; Richards, 1984; Londoño Vasquez, 2008)

James (1998) defines EA as "the process of determining the incidence, nature, causes and consequences of unsuccessful language" (p. 1). However, this definition lacks the main objective of EA. According to Crystal (2003), EA is a "technique for identifying, classifying and [more importantly] systematically interpreting the unacceptable forms produced by someone learning a foreign language" through linguistic principles and processes. It was stated, earlier on, by Corder (1974) who made an in-depth study of errors in the learning of second language. He believes that an analysis of errors is important on many levels, namely: (1) trace the learners' progress; (2) define the adopted strategies and procedures; and, (3) supply an effective method to test the hypotheses made about how language is learnt.

In addition to identifying the strategies used by language learners, Richards et al. (1992) state that EA aims to "identify the causes of learners' errors and to obtain information on common difficulties in language learning as an aid to teaching or in the preparation of teaching materials" (p. 127).

Investigating errors and error analysis approach lead to distinguishing two parts of EA: *developmental* and *remedial*. These two sides can be described as the *theoretical* and *practical* sides of EA, respectively. The Developmental Error Analysis concerns the successive phases in errors development that are used for a better understanding of the processes and strategies developed by second and foreign language learners. These phases show that some of the strategies employed by the learners of a second/foreign language are considerably the same as those by which a first language is acquired. (Corder, 1981; Richards, 1984)

Remedial Error Analysis, on the other hand, is considered as "the pedagogical facet of the hypothesis" which allows teachers and course designers to decide on the improvement of the teaching methods (Corder, 1981, p. 25). That is what makes the description of real errors have a great significance in that it provides important considerations, which present 'false hypotheses' generated by learners about the language they are learning. These considerations enable remediation in particular, and teaching improvement in general (Corder, 1981). The Remedial Error Analysis is to be applied in this work.

4.4.2.3.2. Significance of Errors and Error Analysis

EA significance lies in the fact that errors made by language learners are neither considered nor treated as deviations or random slips. They are considered as evidence of the occurrence of the learning process. EA, as mentioned earlier, is practical and real; i.e., it does not predict errors (as CA does); it traces them to discover their sources, and thus, come up with actual solutions. As stated by Al-Khresheh (2016), “EA, as a pedagogical technique, is very effective in pinpointing the L2 [second language] learners’ errors and their causes” (p. 57).

It is important to mention that the absence of errors is not necessarily a sign of correct language competence “because learners may be avoiding the very structures that pose difficulty for them” (Xie & Jiang, 2007, p. 13) which leads, sometimes, to redundancy, personal pronouns, incorrect tense and verb forms, etc. However, the presence of errors proves that the learners are trying to learn and trying to make and prove hypotheses they have generated about the language they are acquiring.

Hence, the study of errors and the application of an error analysis approach can be seen to serve three different parties: *Teachers* (and course designers), *researchers* (in the field of language learning) and *learners* themselves.

4.4.2.3.2.1. Error Analysis Significance to Teachers

Teachers are the first to notice and detect learners’ errors. The role of teachers was limited to the correction of these errors. However, immediate correction is not an effective tool in teaching since it “bars the way to the learner testing alternative hypotheses” (Corder, 1981, p. 11). Thus, teachers had better allow the learners test their own theories and see if they can produce the correct utterance because “making a learner try to discover the right form could often be more instructive to both learner and teacher" (Corder, 1981, p. 11).

That is why, studying the errors provide teachers with valuable information such as type and frequency, which show where the students face the most problems (Dulay, Burt & Krashen, 1982). Giving this, teachers can do more than correcting the errors; they adapt the methods used to teach those particular areas where learners usually fail. For instance, they can focus more on those areas, provide supplementary practice, devote adequate time, use appropriate degree of simplification, supply with extra material, etc. On the whole, teachers became "more concerned with how to deal with these areas of difficulty than with the simple identification of them" (Corder, 1981, p. 5).

In addition, errors committed by language learners give valuable feedback, which can tell the teachers how much advancement the learners have achieved -so far-, and what is left to be attained. As Corder (1981) explains, if teachers carry out 'a systematic analysis' of errors they will be informed about "how far towards the goal the learner has progressed and, consequently, what remains for him to learn" (pp. 10-11).

Furthermore, EA investigates the origins of the errors which are as important as the errors themselves. Richards et al. (1992) state that EA helps "identify the causes of learners' errors" (p. 198) in that the causes explain why exactly learners commit errors. The study of the sources of errors allows teachers and syllabus/course designers to come up with remedial activities and courses in order to overcome the gaps in learning that lead to the occurrence of the errors. It is imperative to note that these gaps can result from the teaching strategies or techniques. Therefore and in addition to remedy, EA helps verify and assess if the approaches and methods selected by teachers are effective and successful or they are themselves potential sources of the errors. According to Richards et al. (1992), EA is used to “obtain information on common difficulties in language learning as an aid to teaching or in development of teaching materials” (p. 198).

Another gain for teachers applying EA and systematically study the errors made by learners is that it can help them “enhance students’ ability of self-correction” (Ellis, 2009, p. 4). In other words, learners become aware of the fact that errors may occur and that such errors are welcomed in learning for being a positive sign of the presence of the learning progress. Learners, therefore, would become more careful and pay intensive attention to the areas with which they usually find difficulties.

4.4.2.3.2.2. Error Analysis Significance to Researchers in Language Learning

As mentioned above, the view towards errors committed by language learners has changed. They are no longer treated as slips or ‘lapses’ which need correction only; they are seen as an important ingredient in the learning process. It is no longer enough nor practical to predict errors and problematic areas through a contrastive comparison between the system of the second/foreign language and that of the first language. The purpose of such comparison was mainly to inform teachers of these difficulties so that they can provide more focus on them in an attempt to avoid them. Nevertheless, teachers have noticed two important things: the first is that these researchers’ contribution did not come up with any new information for them; i.e., they were able to find these errors and treat them by themselves. The second issue is that there were common errors which were not predicted by the researchers. (Corder, 1981)

Given these data, linguists and researchers in the field of second and/or foreign language learning started to dig in the sources of these errors. According to Corder (1981), researchers carried out deep investigations of errors in order to explain some phenomena that appear in the learning process of learners and understand “how language is learnt or acquired, what strategies or procedures the learner is employing in his discovery of the language" (p. 11). In other words, researchers are provided with "evidence of the system of the language the learner is using at a particular point" or simply by what method the learner "acquires or learns a second language and while learning it what sort of strategies he employs" (Corder, 1981, pp. 10-11).

Hence, EA allows "determining areas that need reinforcement in teaching" (Corder, 1981, p. 12). This valuable information provides researchers and linguists with an adequate -to some extent- material, which allows finding, developing and innovating methods and techniques that make it possible for both teachers and learners overcome and avoid common errors. Researchers' mission, therefore, has shifted from predicting errors to defining the sources of actual errors and finding solutions to them. They are also supposed to create strategies that can enhance teaching approaches and learning methods.

This investigation in the causes of errors leads researchers (Corder, 1967; Dulay & Burt, 1972; 1974; Allen & Corder, 1975) to reveal that not all errors are caused by interference of learners' mother tongue. As Al-Khresheh (2015) mentions, "interlingual interference from first language (…) is not the only reason for the occurrence of errors" (p. 123). Earlier on, Londoño Vasquez (2008) states that "many errors seem to have multiple origins" and that interference of mother tongue shapes a small part of these origins (p. 138). Jabeen, Kazemian and Shahbaz (2015) lists some of these sources as "lack of competence, ignorance of rules and gaps in vocabulary" (p. 60). In addition to that, some errors can be due to "acute external influences" that are not referred to any of the languages (first or second) such as: *lack of time*, *stress and pressure*, *tiredness*, *distraction*, etc. (Jabeen, Kazemian & Shahbaz, 2015, p. 61)

4.4.2.3.2.3. Error Analysis Significance to Language Learners

The first concept about errors that learners should bear in mind is the fact that making mistakes and committing errors are accepted in learning (Corder, 1967). This fact can help learners gain confidence about their abilities and skills when using the language they are learning; speaking or writing. As claimed by Pappas (2015), mistakes and errors ‘boost’ learners’ “confidence and self-esteem because they are empowered to find their own solutions”. Many learners were thinking that errors are signs of failure and this false thought led to disrupting their learning progress. That is why learners must be informed that committing errors while learning a language prove that they are actually learning. As Pappas (2015) summarises it, “mistakes should be viewed as amazing opportunities to grow, rather than resounding failures that stand in the way of the learning process”. It can also be noted that they are using their capacities and applying certain skills -to use the language- that are different from simply imitating or reproducing utterances used by native-speakers of the language. In other words, learners are experimenting theories or ways they have generated -intentionally or automatically- to check their reliability and correctness.

Corder (1981) emphasises that committing and recognising errors are “indispensable to the learner himself” and this is their “most important aspect” (p. 11). Making errors is regarded as “a device the learner uses in order to learn” and to discover the rules of the language being learnt (Corder, 1981, p. 11). If learners are directly given the correct version of a particular language concept, they may not pay enough attention to it and so, easily forget it in the future. However, if they struggle with it a little bit (make mistakes or commit errors) and formulate a remedy on their own; i.e., form their own hypotheses about it, test them, then reach the correct form; they will retain this concept and become aware of it every time they use it. Errors, thus, are “a way the learner has of testing his hypotheses about the nature of the language he is learning” (Corder, 1981, p. 11). Going through these steps when learning allows learners to “expand their knowledge base in a productive and profound way” (Pappas, 2015).

4.4.2.3.3. Error Analysis Procedure

As errors gain importance in language learning, they should be systematically studied through an organised procedure to achieve the objective of improving language learning pedagogy. Hence, error analysis procedure involves a set of stages in order to be applied. These stages have gone through a series of development, addition and selection through previous researches. Originally, Corder (1974) has set the basics of error analysis proposing three major stages which are: “recognition, description and explanation”, claiming that they are “logically dependent upon each other” (p. 126). That is teachers, as well as researchers, have to detect and recognise the learner’s errors, describe them by showing what language point the learner used incorrectly. Then, they must explain those errors in an attempt to understand how they are considered errors and why the learner committed errors in these particular points.

Further, Van Els et al. (1984) suggest the same stages adding two more to the list: *Evaluation* and *prevention* or *correction* of errors. The former stage enables both teachers and researchers to define the value and significance of errors. The latter provides learners with feedback on their learning process and use of the language, and provides teachers with efficient strategies to help learners correct their own errors and avoid making the same errors in future productions.

However, in an attempt to follow these steps, few questions, inter alia, might be risen here. For instance, *what kind of learners’ production can be studied for error finding*? *Which is better written or oral production*? *Where can such errors be found*? *Are they randomly taken from any kind of production*?

Regarding these questions, in addition to the fact that errors must be systematically studied to be effective, they cannot be taken from random productions. In contrast, they must be collected from a determined and purposeful corpus. That is what leads to the rearrangement of the stages through which error analysis can be applied. Eventually, Corder (1974) suggests a more effective and set of -five- ‘consecutive’ stages that are as follows:

1. Collection of a sample of learner language;
2. Identification of errors;
3. Description of errors;
4. Explanation of errors; and
5. Evaluation of errors. (Cited in Ellis, 1994, p. 48)

Each of these stages is briefly explained and the application of which in this work is shown below.

4.4.2.3.3.1. Collection of a Sample of Learner Language

The starting point in the application of error analysis approach is to collect an appropriate sample of learner language. It is meant by ‘*learner language*’ what learners produce when communicating, whether in speaking or writing, using the language s/he is learning, typically second or foreign language. As Ellis (1994) puts it, learner language is “the language that learners produce at different stages of their development” (p. 43).

It is important to note that there are a range of aspects that influence learners’ errors such as “the features of the target L2, learners’ proficiency level, learners’ NL and the task involved in data collection” (Guo et al., 2009, p. 120). These aspects are crucial in “collecting well-defined samples of learner language so that clear statements can be made regarding what kind of errors the learners produce and under what conditions” (Ellis, 1994, p. 49).

The following table, suggested by Ellis (1994), summarises some of the main factors to be considered when collecting samples of learner language that are suitable and applicable in EA research.

Table 8. Factors to Consider When Collecting Samples of Learner Language (Ellis, 1994, p. 49)

Factors	**Description**
A Language	
Medium	Learner production can be oral or written
Genre	Learner production may take the form of a conversation, a lecture, an essay, a letter, etc.
Content	The topic the learner is communicating about
B Learner	
Level	Elementary, intermediate, or advanced
Mother tongue	The learner's L1
Language learning experience	This may be classroom or naturalistic or a mixture of the two

In this study, the sample of learner language is already determined and selected. Since the main aim of this study is to shed some light on Algerian science students' difficulties with scientific English, the best sample to be chosen for this purpose is *Scientific Articles*. The sample then is a group of thirteen (13) scientific articles; each one was written by one of the selected students. All articles were written following the IMRaD format (students' choice). Their shared objective is to be published in a scientific journal.

Giving this, the sample collected is described as a *specific* sample, which is seen to be the most applicable. It is worthy to mention that EA samples are categorised into three major types according to their size: *massive sample* (various or different samples of language use collected from numerous learners); *specific sample* (a similar sample of language use collected from a limited number of learners); and, *incidental sample* ("only one sample produced by a single learner"). (Ellis, 1994, p. 49)

Moreover, since an EA approach is applied in this work, the collection of a sample of learner language requires to describe certain aspects (based on Ellis' factors: Table 8 above) in relation to the nature of the targeted population and the underlined aims of this research. Table 9 below represents the adaptation of these aspects and how they are taken into account in the collection of the corpus needed to the current study:

Table 9. Factors Relevant to the Sample Collected in the Current Study

Factors	Description
A- Language (English as a foreign language)	
Medium Genre Content	- Written - Scientific Articles - Chemistry (science)
B- Learner (13 PhD students of chemistry learning English for Specific Purposes)	
Level Mother tongue Language learning experience	- Their level in English: between intermediate and advanced - Arabic (*Note:* French as second language influences these learners' English more than Arabic) - Naturalistic (later, a mixture of classroom and naturalistic experience)

The medium is scientific articles written in English; their overall content is chemistry. The learners' level (the sample population addressed in this study) varies between intermediate and advanced (based on the results of questionnaire). Their mother tongue is Arabic; however, it is imperative to note that these students have studied chemistry in French, and thus, French has -to a certain extent- an impact on their English use.

The language learning experience of the students, before conducting the first analysis- is considered *naturalistic*; i.e., it "takes place in naturally occurring social situation" (Ellis, 1994, p. 12) [these students learnt English by themselves through different strategies and tools such as Internet, books, etc.]. After the first analysis, the students were exposed to a tutoring course (lessons) which turns the learning experience into 'classroom' setting (guided).

4.4.2.3.3.2. Identification of the Students' Errors

After the collection of samples comes the identification of errors within these samples. Though, "what constitutes an error" and how it can be recognised must be clarified first (Ellis, 1994, p. 50). An error is defined as a deviation from the rules or criteria of the language being learnt or used. Therefore, it is important to decide which variety of the English language to be selected in order to use the norms of this variety to compare it with learners' utterances (Standard English is chosen in this context). That is to say, to identify errors, the utterances learners produce must be compared with "what seem to be the normal or 'correct' sentence in the target language which corresponds with them" (Ellis, 1997, p. 16).

Similarly, as reported by Corder (1981), a learner's error is identified or detected "by comparing what he actually said with what he ought to have said to express what he intended to express" (p. 37). In other words, what is thought to be "erroneous utterance" is to be compared with "what a native speaker would have said to express that meaning" (p. 37).

In addition to that, it is vital to distinguish between *errors* and *mistakes*. The current study is concerned with investigating errors -NOT mistakes- in view of the definitions and differences detailed below.

4.4.2.3.3.2.1. Errors or Mistakes

In applied linguistics and second language acquisition, an **error** is "an unintended deviation from the immanent rules of a language variety made by a second language learner" (Ellis, 1994, p. 700). Similarly, Norrish (1983) states that an error is "a systematic deviation that happens when a learner did not learn something, and consistently gets it wrong" (p. 7). These definitions correspond to the errors which result from the learner's lack of knowledge of the rules of the language s/he is learning or false understanding of these rules; i.e., they "reflect gaps in learner's knowledge" (Ellis, 1997, p. 17).

Errors are associated with language learning and they are seen as signs that reflect "an incomplete learning" (Richard & Schmidt, 2002, p. 184). That is why Hendrickson (1987) describes errors as 'signals' that "indicate an actual learning process taking place and that the learner has not yet mastered or shown a well-structured competence in the target language" (p. 387). In other words, in language learning, errors are considered indications or hints that the learner did not or has not yet acquired sufficient language knowledge that enables him to avoid future wrong utterances.

Errors must be distinguished from mistakes or slips in a linguistic context as such because the two terms overlap sometimes. According to Corder (1967), a **mistake** is "a deviation in learner language that occurs when learners fail to perform their competence". It is simply a '*lapse*' that reveals a problem in the performance (speaking or writing). On the other hand, an **error** is "a deviation in learner language which results from lack of knowledge of the correct rule" (Cited in Ellis, 2008, pp. 961-971). To put it another way, mistakes are accidently made; i.e., the learner is not aware that s/he has made a mistake -straightaway- even though s/he is perfectly aware of the correct rule. In other words, the learner might have known the correct version but s/he slipped when writing or saying the words. ***Mistakes*** are "performance based" and, once noticed, can be corrected by the learners since they are familiar with the rule or the correct utterance (Koltai, 2015). In contrast, *errors* cannot be corrected by the learner because they occur mainly as a result of lack of knowledge and ignorance of the rules.

Moreover, it was noticed in several occasions that the term *mistake* is used to describe a wrong performance or an incorrect utterance in the speech of the learners rather than in their writing (probably because they revise their writing). For instance, "she don't know that!" instead of "she DOESN'T know that" is usually considered a mistake if the performer knows how to use the auxiliary to do. The same example, however, can be considered an error if the performer is not aware of the use of the auxiliary; i.e., ignorance of the rule. (Ellis, 1994; Koltai, 2015)

4.4.2.3.3.2.2. Types of Errors

The second issue to be taken into consideration when identifying errors is their types. Errors can be categorised from several sides. As far as identifying errors is concerned, Corder (1971) distinguishes two major types of errors in relation to the appearance of the utterance; whether the form of the utterance appears to be correct or incorrect. An error can be *overt* (i.e., the deviation appears in the surface of the utterance) which is easy to be detected, or *covert* (i.e., the utterance is 'superficially well-formed' but does not match what the learners intends to express) which requires to reveal the meaning intended so as to decide whether it is erroneous or not. (Corder, 1971; Ellis, 1994).

Giving this division, every utterance under investigation should be regarded as erroneous until proved to be correct; i.e., the utterance might seem to be correct but the intended meaning requires a different one according to the context in which it is used. In this case, interpretation of the intention of the learner is crucial. According to Corder (1971), there are three possible ways of interpretations: "normal, authoritative and plausible" (p. 60). The first interpretation is when the analyst (teacher/researcher) is able to interpret the utterances according to the norms of the language being learnt. The second is done by asking the learner -himself- about the intended meaning expressed; if it is incorrect, the analyst may reconstruct the utterance. The third one is achieved through referring the utterances to the context in which they are made or translating these utterances (if possible) into the learners' mother tongue.

Figure 13 summarises how each of these methods of interpretation can be conducted as suggested by Corder (1981, p. 23)

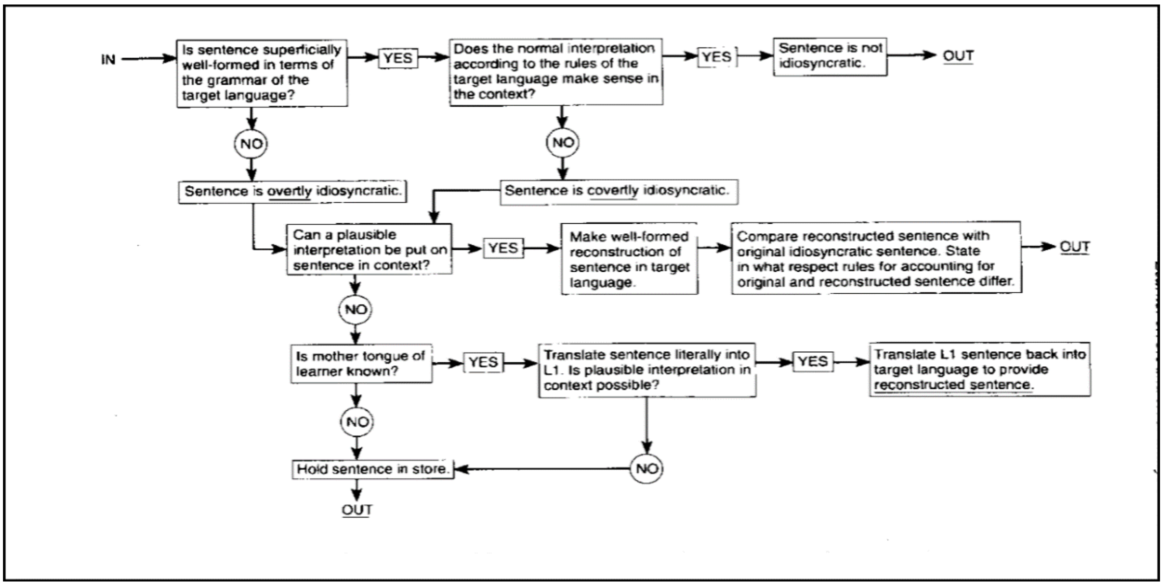

Figure 13. How to Interpret Utterances to Decide whether Erroneous or not
(Corder, 1981, p. 23)

***Note*:** the terms 'idiosyncratic' and 'idiosyncratic dialects' are how Corder in different works referred to 'errors'.

Errors were identified by way of reading through the collected papers and scanning for deviations and wrong utterances. In order to recognise those deviations, certain characteristics were taken into consideration. First of all, formal English was set as the standard -target- language to make the assessment of the errors; i.e., students' words and sentences that are thought to be erroneous are compared with formal English norms. The question of being it American or British (for the fact that the students are exposed to both varieties since they read and learn English from different resources) does not cause a problem unless they use both varieties in one paper. Second, as stated above, the extracted and collected errors were classified in principle according to whether they appear to be wrong (overt) or well-formed but erroneous in the context (covert).

4.4.2.3.3.3. Description of Errors

The third stage in EA is to describe the identified errors. The description of errors involves classification and categorisation of errors. Such categorisation can have several forms according to the basis on which errors are classified. There are some known classifications that are done over a linguistic basis. For example, Pulitzer and Ramirez (1973) propose to classify errors into "morphology, syntax and vocabulary" errors (Cited in Ellis, 1994, p. 54). As a rather specific classification, Burt and Kiparsky (1972) suggest linguistic categories through which errors can be classified such as: "the skeleton of English clauses, the auxiliary system, passive sentences, temporal conjunctions, and sentential complements". Each of these categories can be divided into even more specific subcategories, such as: *The auxiliary system => auxiliary 'do' + auxiliary 'be' + auxiliary 'have'.* (Cited in Ellis, 1994, p. 54)

In addition to the linguistic-based categorisation of errors, there is a surface-based one; i.e., the classification of errors according to the surface or appearance of the utterances in question. An example of such classification is that suggested by Corder (1981), which describes what makes an utterance erroneous from the form and constituents of the utterance. Table 10 presents a summary of the main types of errors that are based on the surface of the sentences:

Table 10. Matrix for Classification of Errors (Corder, 1981, p. 36)

	Graphological Phonological	***Grammatical***	***Lexico-semantic***
Omission			
Addition			
Selection			
Ordering			

Omission refers to a component, which is omitted while it should be mentioned. Addition is the opposite of omission; it indicates elements that are mentioned which are not supposed to be there. Errors of selection represent the wrong choice of an item instead of another. Errors of ordering refer to wrong placement of one or more of the sentence components. For a better explanation of this categorisation, Table 11 below provides examples of each category.

Table 11. Examples of Corder's Surface Categorisation of Errors (Erdogan, 2005, p. 52)

Omission	
Morphological omission	*A strange thing happen to me yesterday.*
Syntactical omission	*Must say also the names?*
Addition	
In morphology	*The books is here.*
In syntax	*The London*
In lexicon	*I stayed there during five years ago.*
Selection	
In morphology	*My friend is oldest than me.*
In syntax	*I want that he comes here.*
Ordering	
In pronunciation	*significant for 'significant'; plural for*

	'plural'
In morphology	*get upping for 'getting up'*
In syntax	*He is a dear to me friend.*
In lexicon	*key car for 'car key'*

However, unlike linguistic categorisation, this one is superficial; i.e., "insufficiently deep or systematic" (Corder, 1981, p. 37). In other words, omission or wrong selection does not really describe all sorts of errors. By means of illustration, English learners commonly commit errors when using articles. That is adding an article where it is not required or omitting one where it is needed are classified as different kinds of errors: addition and omission, respectively. Whereas, it would be "explanatorily more useful to consider them both as evidence for an incomplete knowledge of the system of identification or specification" (Corder, 1981, p. 37) or simply, lack of knowledge of use of articles. Therefore, the categorisation of errors should be considered from different sides. In terms of the language systems, a classification such as "tense, number, mood, gender, case, and so on" is more adequate, abstract and systematic. For instance, in a sentence like "*I am waiting here since three o'clock*", classifying the error as *omission* or *selection* (*am*: one word instead of *have been*: two words) is not sufficient because it does not explain the error or the difficulty of the learner. It would be better, then, to consider these errors as lack or gap in the knowledge of tenses. (Corder, 1981, p. 37)

In short, it is the duty of the researcher or the teacher to choose which classification system among those to follow according to the objective of the EA study being conducted. Superficially, there are errors of addition, omission, substitution and/or ordering. Regarding language levels that need to be considered, errors are classified as phonology, orthography, lexicon and grammar errors. In view of the previous suggestions, the combination of these categorisation systems is possible. For instance, errors can be classified as: *Syntax => passive sentence => verb form => omission*. In the present investigation where the objective is to obtain a clear image of science students' difficulties with English (as learners) through analysing their errors, these classification systems can be adapted to describe the errors in order to elucidate their causes and sources.

Since the description of the students’ errors involves classification of the erroneous utterances into types and categories, tables are seen to be the most appropriate tool because they allow the presentation of a large amount of data in an easy-to-read format and in a small space. Therefore, some tables were created in this paper to demonstrate statistical information of the frequency of the detected errors to make the best use of them and their analysis in this research and to achieve the underlined objectives.

Before proceeding with the classification of errors, it is imperative to state the language aspects to be highlighted in the description of errors in this study; i.e., the focal points of error detection and analysis. Errors are classified as whether they are lexical, grammatical or stylistic. The reason for this classification of errors instead of a more in-depth one (morphological, syntactic, semantic, etc.) is the nature of the target population. As discussed in earlier phases of this work, these students are not concerned with GE but with EST; and so, it is not necessary for them to learn aspects of language from a linguistic point of view (morphology, phonology, semantics, pragmatics, etc.). In other terms, they do not need to learn English linguistics as much as they need to learn the use/usage of the language. That is, learning the rule with simple explanation of use in certain conditions and cases is more important than knowing the origin or to what aspect the rule belongs. For the reason that the study is about and directed to science students, there is no need -at this stage- to classify the errors in a rather detailed manner; however, a deeper classification can be processed for further linguistic research. A simple fact, the more details shown the more difficult it is for science students who are again concerned with only EST (learners’ needs). They need to learn how to write, read and communicate their work. None of these skills require them to a certain level to have training in linguistics. Consequently, the tables (Table 12 to Table 17) that demonstrate how errors are classified in the current investigation are listed below.

It is important to mention that the tackled elements are not the only problems that face science students; however, they are among the most frequent ones. These elements are also seen to have a great impact on the students' writing as they may hinder comprehensibility of their communication, and also lead to the rejection of their papers. Science is already difficult and accurate, and so, it should be properly communicated and well put in shape and in meaning.

The errors are so numerous that it is not possible to mention them all in the tables (or in text format). Therefore, the tables used here are for providing the types of errors and the frequency of each. Frequency statistics are presented for a two-fold purpose: first, they prove that the referred to item is an error not a mistake; second, they provide insight of the problem and show the areas of weaknesses of the students which is the bottom line of the analysis.

Table 12 is used to present a general classification of the collected errors; all the three types that are chosen in this study to encompass the detected errors. This classification facilitates the study of errors and shows the most problematic area(s).

Table 12. General Classification of Errors

Linguistic Level	**Frequency of Errors**
Grammatical	
Lexical	
Stylistic	
Total	

Table 13 is devoted to sort the grammatical errors into sub-categories and classify them according to their frequency. This classification aims to highlight the language and grammatical points that are difficult for the students.

Table 13. Types of Grammatical Errors

Grammatical Errors	Sub-category	Frequency
	Total	

After classifying all grammatical errors, more specified classifications are necessary for the different aims of the study. In order to elucidate the students' difficulties with -English- scientific writing, particular factors are taken into account. These factors are very important to these students and to their objective of learning English / EST. As a case in point, tense use and consistency are especially important to be highlighted, not in general, but in each of the sections of the scientific article. Table 14 below is used to detect students' use of tenses in each part of the scientific article compared to a -general- tense pattern (the correct choice) in addition to the justification of the selection of a certain tense for a given purpose.

Table 14. Students' Use of Tense in SA Sections

Section	Students' Choice	Appropriate Tense	Justification
Abstract		Past tenses* Present simple	The choice of tense depends on the kind of information being conveyed (esp. in introduction and discussion) (*Past tenses include past simple and present perfect)
Introduction		Past tenses Present simple	
Methods and Materials		Past tenses	
Results		Present simple Past tenses	
Discussion		Present simple Past tenses	
Conclusion		Present simple Future	

Note: the tenses provided in this table are not the only possible tenses; the type of data, the objective of each piece of information being communicated and the time of execution are examples of factors that affect the choice of tense in each section (detailed in the lessons).

Similar to grammatical errors, lexical and stylistic errors are also classified into sub-categories. Table 15 and Table 16 below are used to detail the lexical and stylistic errors, respectively and present their frequency in order to deduce the areas that should be highlighted in the tutoring section of the study.

Table 15. Types of Lexical Errors

Lexical Errors	**Sub-category**	**Frequency**
	Total	

Table 16. Types of Stylistic Errors

Stylistic Errors	**Sub-category**	**Frequency**
	Total	

4.4.2.3.3.4. Explanation of Errors

Among the five stages in EA research, the explanation of errors is the most important one for language learning research because "it involves an attempt to establish the processes responsible for L2 acquisition". It is concerned with "establishing the source of error", that is, explaining why it is made (Ellis, 1994, p. 57) and this is the "ultimate object of error analysis" (Corder, 1981, p. 24).

An attempt inter alia to explain errors is to refer them to '*psycholinguistic*' sources which "concern the nature of the L2 knowledge system and the difficulties learners have in using it in production" (Taylor, 1986. Cited in Ellis, 1994, p. 57). This is particularly convenient and applicable in this study for the aforementioned objective. On this basis, the psycholinguistic sources of errors can be summarised by the following diagram.

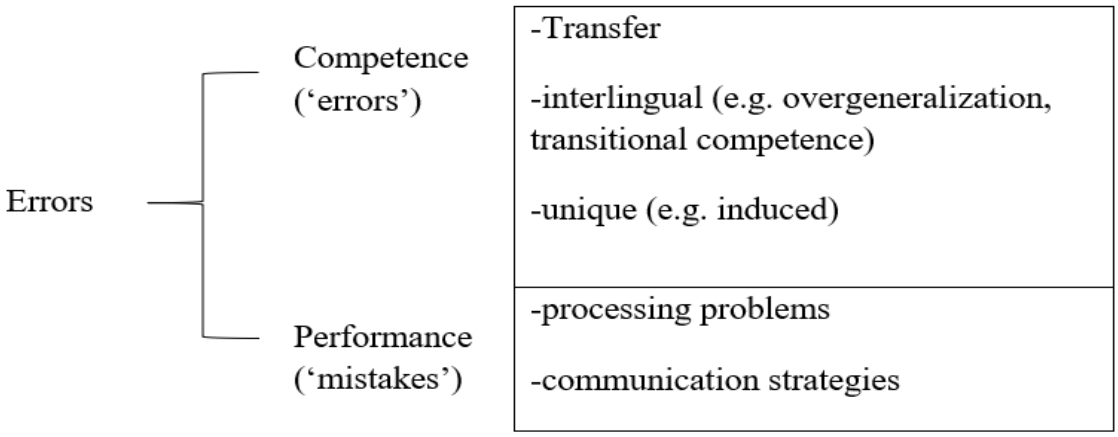

Figure 14. Psycholinguistic Sources of Errors (Ellis, 1994, p.58)

***Note*:** this study is concerned with (competence) errors only, not mistakes (performance).

4.4.2.3.3.4.1. Interference Sources

Transfer errors are those errors, which result from the use of some of the learners' first language (rules, words, structures, etc.) in the production of second/foreign language. This source of errors is also referred to as '*interference*' (Dulay & Burt, 1974) and '*interlingual*' errors (Corder, 1974). These errors are the result of using elements from one language while speaking or writing a different one (Richards, 1984).

Corder (1974) suggests the scheme below, which illustrates interference (interlanguage) of language A to target language. Language A refers to the mother tongue or to another language learnt and used as the first language (such as French to the subject of the current study).

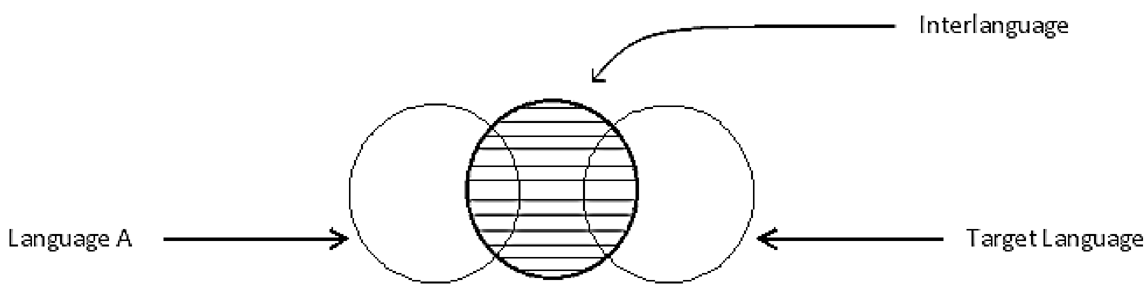

Figure 15. Interference between First Language and Target Language (Corder, 1974, p. 151)

Bernd (2017) states that interference errors are not only "errors occurring during the acquisition of a foreign language due to the incorrect transfer of structures from the mother tongue (L1) to the foreign language (L2)" but also "from a previously learnt foreign language (L2) to a new foreign language (L3)" (p. 8).

Such interference is 'unavoidable'. It can though be both positive and negative. In other words, interference is seen to be beneficial when some structures in the mother language correspond or are similar to structures from the target language (Khansir, 2012). However, when the "structure of the second language differs from that of the mother tongue, we can expect both, difficulty in learning and errors in performance" (Wilkins, 1972, p. 198).

Therefore, language learners already hold some learning habits from their first language or a language they have already learnt or mastered. Some of these habits can help them learn the new language system while others may create problems. In simple terms, "those elements that are similar to his native language will be simple for him, and those elements that are different will be difficult" (Littlewood & William, 1984, p. 17).

Level of learners as well as the subject being communicated can both contribute to the definition of the source of errors made by language learners. The more the learners advance in their level, the less transfer errors occur. The subject (science) which they were dealing with mostly in French, English or German (to be mentioned later) lead to few (if any) transfer errors from Arabic as their mother tongue.

4.4.2.3.3.4.2. Developmental Sources

Mother tongue interference is not the only source of the errors and EA is not restricted to the study of transfer errors. In contrast, it covers all sorts of errors committed by language learners. It traces several other sources of errors that are not related to first language interference. In addition to that, EA proved that one error can be explained to have more than one source taking into considerations some factors such as context, learning situation, level, etc.

Apart from interference, Richards (1972) distinguishes errors as '*intralingual*' and '*developmental*'. The former is defined as errors which reflect a problem in "the general characteristics of rule learning such as faulty generalization, incomplete application of rules and failure to learn conditions under which rules apply". There are four distinct types of this source of errors. (1) '*Overgeneralization*' covers errors where the learners form a different generalisation of a structure on the basis of other structures of the target language. (2) '*Ignorance of rule restriction*' occurs as a result of the use of a given structure in a context where it does not apply. (3) '*Incomplete application of rules*' refers to instances of failure to apply a certain structure/rule to produce meaningful and acceptable utterances. (4) '*False concepts hypothesised*' arises from incorrect understanding of some distinctions in the target language (Cited in Ellis, 1994, p. 59).

An illustrative example of intralingual errors is that presented by Norrish (1983). The use of *the infinitive with to* after the modal must (e.g., *I must to go*) can be due to the learner's familiarity with verbs such as *want* (+ to), *need* (+ to), *have* (+ to) and *ought* (+ to). The learner, then, overgeneralised the use of '***to***' after verbs or modal verbs (*must* + *to*) which led him to create such an utterance. (p. 7)

Developmental errors, on the other hand, refer to errors that result from hypotheses generated by the learners on the basis of their -partial- knowledge of the target language. These errors are considered significant because they proved the existence of a *system* formed by the learners in the process of learning the target language; i.e., the learning actually occurs (Richards, 1972. Cited in Ellis, 1994). Dulay and Burt (1974) describe them as "the same as those observed in children acquiring the target language as an L1" (p. 129). In other words, learners of second/foreign language use certain strategies that are similar to natives learning their first language. In this regard, developmental errors prove that "natural processes of learning are involved in the learning of the target language" (Ellis & Shintani, 2014, p. 62).

However, developmental and intralingual are not treated as different sources of errors (Ellis, 2008). They both (in addition to mother tongue transfer) lead to the interpretation of errors, which says, "previous learning may influence later learning" (Richards, 1984, p. 6). Previous learning can be that of first language, target language or another language, which has been already learnt.

4.4.2.3.3.4.3. Unique Errors

When the errors do not belong to either of these sources, they are described as '*unique*' (Dulay & Burt, 1974). As a matter of fact, investigating errors revealed that numerous reasons can cause errors in language learners' productions that are neither interlingual nor intralingual. Such errors can refer to teaching flaws, inadequate strategies of teachers, gaps in the syllabuses or unawareness of the correct patterns, or else, a combination of these reasons. (Khansir, 2012)

Moreover, learners were noticed to create some techniques in an attempt to avoid making errors, especially when they do not find words or expressions to communicate their thoughts. The errors committed as results of these strategies are referred to as: '*communication strategy-based errors*' which occur when learners "employ some near-equivalent L2 item to replace a required form that is found lacking during communication in target L2" (James, 1998. Cited in Guo et al., 2009, p. 132). They are also called '*paraphrase communication strategy*', which can be found in three forms: "approximation (e.g., *animal* for *horse*), word coinage (e.g., *air ball* for *balloon*), and circumlocution; i.e., learners talk their way around the word that they do not know (e.g., *when you make a container* for *pottery*)" (Tarone, 1980. Cited in Guo et al., 2009, p. 132).

Furthermore, some errors can be related to weaknesses or failure of memory (Gorbet, 1979); to be precise, forgetting; i.e., when learners have “a total blank, not being able to recall the item at all”. Forgetting is usually “associated with lack of practice, length of time since acquisition, obliteration by intervening learning, and unclear understanding” (p. 22). Even transfer from the first language is not possible in this case; neither positive nor negative because the differences between the two languages (first and target) are ‘too great’. (Allen & Corder, 1975, p. 266)

In addition to the previously mentioned sources, Richards (1984) listed a group of factors that may influence learner language and lead to the occurrence of errors. Some of these factors are the effects of the sociolinguistic situation, the modality of exposure to the target language and the modality of production, the age of the learner, the instability of the learner’s linguistic system, and the effects of the inherent difficulty of the particular item being learnt. (p. 2)

In the light of this, the explanation of errors also involves a classification on the basis of their sources (*interference*, *developmental* and *unique*). In addition to the classification, statistics of frequency are required to show which among the sources has the major impact on the students’ writings.

Statistics of the origins of the detected errors are presented in Table 17 below. These statistics reveal which source is the most problematic and affects the students’ writing.

Table 17. Taxonomy of Sources of Errors

Errors’ Sources	**Frequency**
Interference	
Developmental	
Unique	
Total	

Recognising the sources of errors leads to elucidate the difficulties encountered by the student (which is the main aim of this work) and understand the real reason why they commit errors. It also helps defining the areas that should be highlighted in the tutoring phase. Consequently, this explanation enables to find and design feasible and applicable solutions to overcome these difficulties and avoid future errors. It also allows creating a guide for science students to help them write correctly and communicate their findings in an acceptable way.

4.4.2.3.3.5. Evaluation of Errors

This stage is not necessarily involved in every EA study. According to Ellis (1994), "many studies do not include" the evaluation of errors and it is usually "handled as separate issue" (p. 48). The reason might be the fact that unlike the four previous stages of EA which study errors from the learners' point of view, evaluating errors "involves a consideration of the effect that errors have on the person(s) addressed" (p. 63). Nevertheless, it keeps the same objective of EA: "improve language pedagogy" (Londoño Vasquez, 2008, p. 140). Another reason might be the fact that errors are evaluated from the evaluators' perspectives, which make the evaluation relative and thus varies from one evaluator to another. (Davies, 1983. Cited in Ellis, 1994)

On this basis and in order to evaluate errors, it is crucial to determine 'the addressees (i.e., the judges)', the errors to be judged and the criteria to be judged about. The addressees can be native speakers of the target language as they can be non-natives. The errors are taken usually from written productions of language learners. The judges rely on a set of criteria and procedures to evaluate "the seriousness of an error"; i.e., to what extent an error is problematic and what kind of errors should receive more attention than others should do (Ellis, 1994, p. 701). Measuring the seriousness of errors helps identifying the areas of difficulty in the target language for a particular group of learners, determining the source of errors from a broader point of view and providing an efficient remedy for these learners. The evaluation of errors may involve their correction as well.

Furthermore, it is important to note that error evaluation "is influenced by the context in which the errors occurred" (Londoño Vasquez 2008, p. 140). In other words, the very same error can be evaluated differently depending on who have committed it, when, where and how.

In brief, the evaluation of errors leads to the distinction of two types of errors in reference to their degree of seriousness as well as their impact on the *intelligibility* of the utterances (Ellis, 1994). These types are "*global*" and "*local*" errors. The former is called global because it affects the whole sentence, such as word order; whilst the latter occurs when one part of the sentence is erroneous and -mostly- do not affect the general meaning of the sentence, such as wrong tense or verb form (Ellis, 2008). Global errors 'hinder' comprehension of utterances like in the sentence below where the intended meaning is not clear and cannot be deduced:

I like bus but my mother said so not that we must be late for school. (Erdogan, 2005, p. 264)

Local errors, on the other side, do not prevent the understanding of the conveyed message. For instance, the verb form (*hear*) is what made the following sentence erroneous but the meaning can be understood:

If I hear from her, I would let you know. (Erdogan, 2005, p. 264)

It can be said that the evaluation of errors in this study is conducted in parallel with the previous stages (especially description and explanation). Evaluating errors can be done over two steps; first, based on the statistics collected from the previous stages of the analysis which enables to determine the degree of seriousness of each type of the errors detected; and second, by classifying those errors into *global* or *local* errors to highlight their impact on the intelligibility of the entire paper. Global errors affect the entire organisation of the sentence, which leads to the misinterpretation of the conveyed idea, and thus, mislead the research being done (or part of it). Local errors affect one part of the sentence; in most cases, they do not affect meaning but still they must be dealt with since they may cause rejection of the paper.

4.4.3. Tutoring: The Lessons

The analysis approach employed in the present study does not aim only to recognise students' errors and mistakes but also to seek and to investigate possible solutions in order to avoid committing such errors in future writing. Analysing students' errors, as stated by Richards (1984), has an important "Applied Linguistic justification" in that it provides data for "theoretical discussion and, after evaluation, feedback to the design of remedial curricula" (p. *ix*). That is what Corder (1967) mentioned earlier; the errors committed by learners are "a major element in the feedback system of the process we call language teaching and learning" (p. 35). On the basis of the information provided by errors, the teacher "varies his teaching procedures and materials, the pace of the progress, and the amount of practice which he plans at any moment" (Corder, 1967, p. 35).

Therefore, the analysis of the scientific articles and the identification of the students' errors and their origins shed light on (some of) the difficulties and challenges that these students encounter when writing in English. Identifying such difficulties allows "EFL/ESL teachers pinpoint their students' weaknesses and hence revise their teaching methods and learning materials accordingly" (Al-Khresheh, 2011, p. 429). The next step, then, is to select or create a suitable way that enables the students to overcome these difficulties and suggest a solution to enhance their scientific writing in particular and communicating with English in general. This step plays the role of a remedy, which is carried out in the form of a course (lessons), presented to the students as a special type of tutoring in form and content. Arguably, the overall objective of the analysis approach applied in this study is to improve teaching English for NNS science students and provide better teaching methods. According to Sharma (1980), “error analysis can thus provide a strong support to remedial teaching” (p. 75).

4.4.3.1. Aims of the Designed Course

This phase functions as remedial work based on results from the two previous steps: The questionnaire and the first analysis. The designed course (the lessons) covers, to the extent feasible, the major areas of weaknesses noticed from the previous results in an attempt to raise students’ level and enhancing their performance in dealing with scientific English. Apparently, it is insufficient for the students to become aware of their problems with scientific English; practical methods seemed rather adequate to solve those problems. Presenting essential information for the students in the form of lessons (tutoring) has been seen fit to remedy for the aims listed below:

- To raise students’ level and strengthen their performance in the areas that challenge them the most.

- To bridge the gaps and repair the shortcomings in their English competence and knowledge by providing necessary information.

- To provide a convenient guide on how to correctly communicate science in English, particularly how to write scientific articles.

4.4.3.2. The Lessons: An Overview

A group of five lessons were held with the sample students of this study. These lessons were important for both participants. For the researcher, it is to test and assess the method of the treatment (for future applications and recommendations); and for the students, it is to improve their writing of the scientific English. These lessons are about

EST, the scientific writing and the scientific article, of interest in this research. The usual lexical and grammatical aspects in the scientific article were provided in the form of short lessons. An extra lesson, about rhetorical and comprehension devices, aims to help them write as well as read in English.

Parts of these lessons are theoretical for having an "explicit theory adds value to lesson study" in terms of knowledge gained (Pang & Ling, 2012, p. 589). During the lessons, there were discussions about the main points presented in order to link them to the students' needs and to show them the usefulness of these points.

Most lessons included many examples that are used to clarify significant details especially those related to language points. Examples play "a central role in the development and the teaching" of several theories (Bills & Watson, 2008, p. 77). Thus, the examples were used for the following reasons:

-providing better and clearer explanation;

-containing a lot of details that needed to be discussed individually;

-understanding is better than memorising; *and*,

-breaking the ice of too much theory.

Concerning the lessons' planning, most of the lessons are divided into three phases: Introduction, presentation and production. In the *introduction* phase, the main concept to be discussed is announced sometimes through a group of simple questions, which aim to set the context of the lesson and activate the *English mode*. The second phase is the *presentation* in which the necessary details are provided through explanation, discussion and argumentation. Interaction in this phase allows the students to engage in the lesson and enquire about the presented notions. The last phase is the *production* (the students are not asked to write articles at this stage). Production here is to make students summarise the acquired knowledge in the lesson and how they can benefit from it in their writing in order to check their understanding and avoid ambiguous or insufficient learning.

Each of the lessons took three to four hours (sometimes more) depending on the content and the discussion. The setting was similar to a classroom with a teacher and students. The teacher plays a key role in shaping students' learning (Darling-Hammond 2000) because most of the presented concepts could not be simply self-learnt. Lesson plans and handouts were used with the purpose of: 1. determining the aims and objectives, 2. organising the data and information being presented, 3. checking the students understanding of the lesson through debating and assessment, and 4. controlling the time and order of prepared units.

During this experiment, a more open teaching style was easily created (students are adults and seem to be able to tackle and be responsible for their own learning problems when they come to surface). Students were really interested and motivated as they interacted with the teacher (the researcher) and their comrades during the tutoring process.

4.4.3.2.1. Why Theoretical

As repeatedly mentioned, the students in question were unfamiliar with the existence and significance of EST. Therefore, some background theoretical knowledge about this field is required to build on and use. Theory teaches the *why*. For example, theory shows why a particular technique works or solves a problem while another one fails. Practical knowledge, on the other hand, helps adapting the very same technique to solve many problems; i.e., the *how*. (Bialostok, Whitman & Bradley, 2012)

The sample students (doctorate students in particular), who are concerned with many activities in the fulfilment of their studies, have a selective and varied mix of backgrounds (Bialostok, Whitman & Bradley, 2012) because they have to read, analyse, select and write, and all that in more than one language. Hence, theoretical knowledge is as important as practical knowledge. For practice -which is writing- was done mostly by the students themselves.

According to Bialostok, Whitman and Bradley (2012), there are "a theoretical side and a practical side to knowledge and both are valuable". That is why an adequate and sufficient amount of theory was presented in the lessons, taking into consideration time and nature of students.

4.4.3.2.2. Physical Setting

Bestowing the lessons was even more difficult than the previous stage in this study. It took longer time because meeting all the students in the same time and place was not always possible. Many students live and have different jobs in different cities. Meetings and lessons were each time held at the University of Constantine 1 (in the Department of English where the researcher belongs; or in the Laboratory of Chemistry in the same university where one of the students works). The five lessons were hold with regard to the different connection software allowed for presenting information, discussing, revising and producing.

The physical sitting differs between a usual classroom sitting and a U-shape way in order to have better interaction between the students and the educator since it was a small class. It also enables to observe all the students and provide one on one help (Shalaway, 2005). By so doing, this enabled the students to participate and feel free to ask questions whenever it was required.

The experiment took also another guise. Students were divided into two groups depending on their level: Students who have good command of English, and students who needed help, guidance and extra explanation of the basic aspects presented in the lesson.

In *Lessons One* and *Two*, there was more teaching than learning compared to the other lessons. This is due to the nature of the content being presented which demanded presentation rather than discussion. For *Lessons Three, Four and Five,* there was more learning because of the use of examples and need to interaction and discussion.

4.4.3.3. Describing the Lessons

4.4.3.3.1. Lesson One: EST and Scientific English

4.4.3.3.1.1. Aim and Objectives

Based on the data gathered from the questionnaire, it was noticed that the students did not have knowledge of what EST is (learning and teaching English for science and technology) but were interested in learning General English. Therefore, this lesson aimed to familiarise the students with the existence of this specific use of English in science to make students understand the role of English in communicating science and technology. This lesson was theoretical and functioned as an introductory lesson to the other lessons to be held after it. The EST lesson covered the principal characteristics of scientific English.

Another part of the lesson acted as an answer to one of the students' questions: "*Why English*?" This question was raised as a reaction to their unanticipated dealing with the English language in their studies. That is why, the lesson included the key features that led to the dominance of English on certain fields including science and technology. The chosen features shown here were seen to raise their awareness and understanding of the need to learn and use English in their studies and so, became motivated and more willing to grasp the coming points.

4.4.3.3.1.2. Included Details

Lesson One was introduced with an overview about English for Specific Purposes (ESP): definition, categories and sub-division in order to make the students aware of the existence of ESP. Such an introduction allowed students to be acquainted with the position of English for Science and Technology (EST) and understand the specific use of English for science as compared to General English (GE). (cf. Appendix 4)

In the presentation of *Lesson One*, students were shown how and why EST is concerned with their needs. These features provided the students with the first keys to writing (in addition to reading scientific texts in English.)

In addition to that, recognising the reasons that support the dominance of the English language on science and technology fields helped students comprehend why they have to write and publish in English. These details acted as explanation and motivation to learn and use English.

4.4.3.3.1.3. Students' Interaction and Feedback

The students appreciated the idea that recognising and learning about EST would improve dealing with their scientific studies and technological requirements. Since these students have been studying mostly in French and they knew they should publish in English; this lesson has substantially raised their motivation in taking the learning phase. They have understood the role and position of English in science and mentioned a good example. They said that, in chemistry, they usually utilise many devices, tools and machines that (most of the time) function or come with instructions that are written in English.

As a matter of fact, students have understood the importance of writing, reading and publishing in English (validity, credibility, universality, etc.). In the same vein, they appreciated the idea that if they published in English, their work would be universal contributions to science and not only local work or university requirements.

One of the questions raised by the students was: "*Why learning EST instead of GE is more practical for us?*" To answer this question, the researcher explained that GE is taught and/or learnt as general education for life, literature, culture, relationships, etc. In other words, GE is preferred to EST when the language is the subject being taught/learnt (i.e., the purpose of the course is to learn the language). However, EST is designed as a response to specific learners' needs (such as chemistry students) to acquire different skills and knowledge (like communicating the findings of an experiment).

4.4.3.3.2. Lesson Two: Scientific Writing

4.4.3.3.2.1. Aim and Objectives

Lesson Two (cf. Appendix 6) was dedicated to explain and familiarise the students with the specific characteristics of the scientific writing. The main aim of this lesson was to help the students notice and understand the importance of clarity, objectivity, economy in language and impersonality as well as audience in writing their papers. For the latter, the aspects of clarification and explanation have to be seriously considered, as will be clarified further down.

4.4.3.3.2.2. Included Details

Lesson Two opened with introducing the nature of the scientific writing and showing that it is different from other writing styles. It also presented the characteristics of English scientific writing: Clarity, preciseness, economy of language, objectivity, impersonality. Discussions and examples permitted to elucidate and justify the importance of these characteristics and their significance in communicating science.

The second part of the lesson introduced the concept of *audience* as an important factor in writing in general and in scientific writing in particular. The Knowing their audience helps them make decisions about what information to include, how to arrange that information, and what kind of supporting details will be necessary for their potential readers to understand what is communicated. Audience in their case has three main types: Peers, trainees and general public. Therefore, recognising which type of audience -that the writer/scientist addresses- affects the writing process and outcome on several levels such as the degree of clarity, the amount of information, nature of details, length of the paper, type of words, etc.

4.4.3.3.2.3. Students' Interaction and Feedback

Students showed their willing to learn English for science and technology. The discussions were helpful in making the students understand the presented rules and tips. For that reason, more time and space were given to checking their understanding and asking for examples. Most of the students were capable of understanding at once because they have already noticed some of the criterion discussed in the lesson.

For instance, students considered *the economy of language* as an "interesting and useful" characteristic. Through their different readings, students have noticed the difference between French and English texts -related to their studies- in size and number of words. They said that in English, each idea is expressed directly and in few words only (science); however, in French, a single concept is expressed through long paragraphs including plenty of repetition.

Besides, before *Lesson Two*, none of the students had known the importance of audience and the impact it has on their writings. The only type they had in mind was the journal referees, and even this type of audience is supposed to be considered only at the revision stage of their writing. Audience has become, from this lesson forward, a part of their strategy in writing since it will improve their work. Another appreciated idea by the students was that the best way for writers to know their audience is by imagining who might be interested in reading their papers; only peers or the general public.

4.4.3.3.3. Lesson Three: The Scientific Article per se

4.4.3.3.3.1. Aim and Objectives

Lesson Three (cf. Appendix 7) functioned as a guide to writing the scientific article. It presented important details, the first being the nature of this particular type of papers and why science students have to write it. The second is the layout of scientific articles, mainly the IMRaD format and its significance in science communication as a principal standard layout. It provided thorough description of each component of the SA with tips to use when writing them. The third part stated the essential highlights in each section and the main details that should or should not be included.

Handouts were used to provide the students with extra necessary information including examples, comparison between what is considered good and bad sections. They also contained approaches to write each part and common possible structures.

Lesson Three was considerably long because of the length and importance of the content it covered. For that reason, it was divided into several parts in order to achieve its underlined objectives and help students grasp the presented details.

4.4.3.3.3.2. Included Details

The introduction of *Lesson Three* intended to elucidate the position and significance of the scientific article as their gate to share their findings and recent discoveries, and as a convenient tool to contribute to the heritage of science in the whole world. Students understood that the purpose of the SA is beyond the fulfilment of their post-graduate studies.

The presentation included aspects about each of the components of scientific articles. They were presented in the order of their appearance in the article, starting from the *Title* and *Abstract* down to the *References* section. Every section was discussed at the level of importance, information included, specific features, and how and when it should be written.

The lesson also provided the criteria that make each section acceptable and sufficient in addition to how sections are related. Some of the handouts provided comparison between a good and a bad section with reference to the norms mentioned and the writing standards discussed in the previous lesson.

Moreover, as an extra and an important part of a scientific article (usually found in all articles); i.e., tables and figures, students were familiar with using tables and figures in their studies. Some key details were accordingly presented to help them decide which visual to use and what kind of information each of them may represent.

These details were split into parts to guarantee students' understanding of the given information. The students were asked to summarise these details in their own words to check their ability to apply them in their future writings.

4.4.3.3.3.3. Students' Interaction and Feedback.

The students considered this lesson "a useful guide" to writing the scientific article. The details it provided showed them understand how to write each section, what to include and how to link between them. These details enabled them to organise their writing and avoid vagueness, repetition and redundancy.

One of the students' problems was writing the *Abstract* and the *Introduction*. This lesson provided them with details about the type of information that should be put in each of them and their global functions. This lesson made it possible for the students to have a clear outline for each section to achieve consistency in writing their articles and present their findings in an outstanding shape. By so doing, students will be able, for their writing activities, to refer to this lesson.

4.4.3.3.4. Lesson Four: Syntactic and Lexical Features in Scientific Articles

4.4.3.3.4.1. Aim and Objectives

This lesson (cf. Appendix 14) was designed on the basis of the problems spotted in the first analysis of the students' writings. Lexis, tenses and sentence structure were the main points discussed. The students were not conscious about these aspects and they continually and repeatedly made the same errors about the scientific writing style (such as the excessive use of passive voice in every part of their articles).

In addition to that, some errors were discussed and corrected to allow them learn how to revise the language of their papers. However, it was not possible to present all the areas of difficulties to students because of time. The duration of the lesson, which was already long, and the difficulty to provide time for another lesson obliged the division of the lesson into four parts.

In addition to examples, handouts offered sufficient details about each point discussed such as types of words, form of sentences, tense uses, etc. these handouts were handed to the students to check them whenever they intend to revise their writings.

4.4.3.3.4.2. Included Details

Lesson Four was almost as long as the previous one because of the nature of its content. It was about the grammatical and lexical features of the scientific style as a prerequisite in writing scientific articles. Since there were many aspects to present, this lesson was also divided so as not to confuse the students. Each part was presented separately, either directly or through communication means like Skype and WhatsApp.

The first part started by reminding the students that English in science communication is different from GE. The features of the scientific style presented were about avoiding the use of personal pronouns, giving a value judgement and using figurative, ambiguous or redundant language. The provided examples clarified why each of these points should be avoided in scientific writing. In addition, vocabulary in EST and SA were presented along with the problem of wordiness and the appropriate choice of words.

The second part covered the issue of active voice or passive voice preference. It did not only provide basic details about each of the voices including uses, structures, verb forms, etc. (which was accentuated for the low-level students) but also explained the reasons of using each voice and when to prefer one to the other. It also provided explanation of which voice to use in each of the SA sections.

The third part was devoted to explain tense use in the different sections of the SA, which was a noticed problem in the students' writings. Both form and use were explained, first, in general terms (the English tenses), then their specific occurrence in SA sections. This part also included some useful notes about subject-verb agreement with several tips to be taken into consideration.

The last part covered briefly phrasal verbs with the purpose of familiarising the students with the notion and helping them to deal with such verbs to be more careful when using them in their future writings. Some of the students' errors were discussed as examples in the provided details with an attempt to show them practical and valid instances of the errors and their impact on meaning.

4.4.3.3.4.3. Students' Interaction and Feedback

For students, knowing their errors is crucial in the learning process. Errors, if considered with care, will enable them strengthen their ability to write properly because "noticing and admitting our mistakes help us get in touch with our commitments—what we really want to be, do, and have" (Medlock, 2014). The students, then, appreciated the examples of expressions and words that can be replaced or omitted saying that they would like to have more of these expressions and tips.

This lesson allowed students to proofread their papers before they have them published. As mentioned earlier, many papers were rejected because of the mistakes in the language and not in the content (science). Besides, this lesson showed them how to respond to the editors, understand their remarks and be able to correct them by themselves.

4.4.3.3.5. Lesson Five: Comprehension Devices

4.4.3.3.5.1. Aim and Objectives

In addition to writing, students are supposed to read different scientific publications such as books, theses and articles. For that reason, in this lesson, some of the frequent rhetorical techniques and functions were provided (cf. Appendix 19). These rhetorical devices help the students understand the scientific texts they read and offer them a framework of writing as well. For example, expressing *cause and effect*, in addition to *describing* a process appropriately are important elements and tools in scientific writing. These devices also allow the students to understand what a writer intends to do with a given piece of text (definition, description, classification, etc.) and thus realise the usefulness of this piece of text.

4.4.3.3.5.2. Why Reading

It is known that reading improves writing. According to Hanski (2014), “no good writing is possible without reading”. Reading for these students involves comprehension, collection of information and knowledge needed in their studies and getting used to the scientific writing style. Students declared that in searching for knowledge and information, they have discovered that with reading they do not only gain knowledge in their field of study but improve their writing as well. Thus, this lesson allows accomplishing two goals at once.

Moreover, reading (with these rhetorical devices and all the previous features in mind) will help the students detect their own errors when writing or revising their papers. It will make them conscious about the style and the possible errors they may commit especially about the language.

4.4.3.3.5.3. Included Details

A part of *Lesson Five* is theoretical because of the nature of information it presented. It included and explained the "Rhetorical Functions and Techniques" established by Trimble (1985).

Lesson Five started with the importance of reading in doctoral studies in order to explain the objective of this lesson. The first part of the lesson listed the *rhetorical techniques* with examples on each. The examples helped students comprehend the techniques and show how they can understand the flow of ideas and the meaning expressed by each piece of the texts they read. The main examples that were seen to be extremely useful for the students were some of the most common linking words and their meaning and use.

After that, the *rhetorical functions* are listed. They are about the function of a given text; i.e., what is done or meant with a given passage (definition, classification, etc.). In reading, knowing the rhetorical functions facilitates the intelligibility and comprehension of what the authors wanted to do with each sentence or paragraph of their text. In writing, it enables the construction of well-written texts in their right place and with a clear purpose.

4.4.3.3.5.4. Students' Interaction and Feedback

The students remarked that, previously, the texts (they usually read) seemed like a block that they had to read and read over again so that they can find the main idea or the relationship between the items. The recognition of the rhetorical techniques helped them read, analyse and understand better.

Furthermore, students understood the different rhetorical functions of scientific texts. It became easier for them to write by considering such functions and techniques. The functions allow the organisation of ideas as they allow the appliance and utilisation of the characteristics of scientific writing style that were presented in previous lessons. By way of illustration, knowing that the aim of inserting a given passage is to *describe* an object saves words and space, and avoids redundancy; and thus, both economy and clarity of language are achieved.

4.4.4. The Second Analysis of the New Set of Articles

4.4.4.1. Describing the Second Analysis

Identifying the problems, discussing and then solving them are the steps of the selected technique that aimed to help students avoid those problems when they write in scientific and technical contexts. In order to check the effectiveness of tutoring, new articles (or parts of articles) written by the same students were analysed. This analysis aimed at testing the students' performance in writing scientific articles after attending the designed course and discussing their mistakes.

This phase of the research also took time. The students had to write new articles taking into consideration the language points that were dealt with during the lessons. They have become their own editors (as far as the language is concerned) and corrected their own papers before they submitted them either to be analysed in this phase or to their supervisors or even to journals.

Thus, the results of the Second Analysis were studied in order to evaluate the effectiveness of the lessons and the usefulness of what was administered in them. The evaluation intended to test whether the treatment chosen and conducted was convenient to solve the problem spotted in earlier stages.

In the Second Analysis, more attention was devoted to the points discussed in the lessons in order to see if the students have understood and applied what they have learnt. In this analysis, students were asked about some unclear points in their articles and their meanings to check the use of particular aspects and see if they have done them by mistake or not.

4.4.4.2. Aims and Procedure of the Second Analysis

The second analysis functions as an assessment that determines whether or not the learning objectives of the lessons have been met. When the students are able to see how they are performing in their new writings, they become able to determine whether they understood the learnt material and whether this material was sufficient for them and answered their needs.

The first analysis showed the students that they have missed important things they should have learnt before; i.e., English for science communication. The second analysis aimed to test whether this gap in the doctorate students' learning was filled, and whether the treatment (lessons) provided the necessary training they have missed.

The Second Analysis, thus, aimed at:

- testing the practicality of theory in this treatment;
- proving that the chosen treatment provided the assistance required by science students;
- verifying the suitability and efficiency of the content of the lessons;
- checking the students' understanding of what was presented in the lessons; and also,
- confirming the hypothesis that if the students were aware of their problems and weaknesses, they would improve their writing.

So as to achieve the underlined aims of the Second Analysis, the following questions were asked.

1. How effective were the lessons in helping students gain relevant knowledge and skills?
2. Were all the problems and difficulties addressed in the lessons?

3. Were the students able to apply what they have learnt to improve their writing?

4. What other benefits did the lessons allow to achieve?

The new articles were analysed in the light of the points that were presented in the lessons. This analysis focused on sentence structure, verb tenses and forms, word choice and use, phrasal verbs in addition to the overall coherence of the texts. The analysis included also checking the discussed features of scientific writing such as the use of personal pronouns and judgement, ambiguity, redundancy and wordiness.

4.5. Material Used in the Treatment

The nature of the chosen treatment required a set of materials (simple and available yet important and useful). Those materials were used in order to accomplish the objectives of this research and make it possible to conduct. They are as follows:

1. The Internet and the e-mail: Helped in regarding the situation of the researcher and the participants: Distance, difficulty to meet, availability of a convenient place.

2. Google apps, mainly Drive and Gmail, in addition to Social Media applications as Facebook, WhatsApp and Skype allowed to hold discussions as well as the revision with the students (sometimes individual discussions) asking about a particular point or detail in the articles during the two analyses. It also helped gain confidence and trust of the students. Finally, it helped to arrange the date and place of the meetings.

3. Lesson plans: preparing the content to be presented is crucial in the learning situation provided in the treatment. The best means that used in the tutoring phase to have an appropriate preparation is "*the lesson plan*". They are really useful tools which enable to: 1. organise the classroom experience; 2. ensure that the learning environment is effective and suitable in each of the lessons; 3. measure the students' learning and understanding; and, 4. allow future editing in case a problem occurs in a lesson, it can be solved in the next.

Lesson plans are important for the educator (the researcher) to organise and structure the ideas and content being presented within a timing framework. Without lesson plans, the lessons could have been done with jumping from one idea to another without any guarantee that the students could grasp the intended concept and the benefit could have been less than wanted or expected.

The essential constituents with whom the lesson plans were organised are: Aims, objectives, direct instruction, guided practice, required supplies (the material required to help the students achieve the main stated objectives) and closure (help students sum up the main points and understand how to use them).

The Teacher's Role: The teacher played a vital role in this *special* learning environment. She acted as a "resource provider, learning facilitator, classroom manager and mentor" (Harrison & Killion, 2007, p. 74) in addition to applying essential activities such as "questioning, listening, reinforcing, reacting, summarising and leadership" (McCrorie, 2018, p. 129).

Conclusion

In this chapter, the design and methodology of the research was reported, and the essential details related to the approach of the investigation were stated. Besides, a description of the research tools utilised in this investigation has been given to allow the assessment of the methodology and the evaluation of the treatment. These tools aimed to detect science students' needs concerning writing scientific papers in English. A questionnaire was designed to generate an overall picture on these needs and a two-step analysis of two sets of articles written in different stages intended to get deeper into these needs.

The pilot study, which included two questionnaires, one to teachers of English in science departments and the other to a larger group of science students allowed narrowing and defining the appropriate sample for the study. The main questionnaire addressed to chemistry students helped to shed light on some sources of the students' problems.

The first analysis aimed to detect the exact areas of weaknesses and difficulties encountered by the students when communicating science in English. The designed course intended to remedy the gap and deficiency in the students' writing in English and meet their highlighted needs. The second analysis aimed to test and assess the efficacy of the lessons in particular and the effectiveness of the study as a whole.

The analysis of students' answers and errors enabled to detect some of the main problems that most science students who write in English might encounter with and the students' needs that can help improving the way English is taught to science students in Algeria and help providing a reference for students to write their articles in English. Therefore, this study will (hopefully) open the door widely to address Algerian science students' needs from English in further investigations.

Chapter Five

Interpretation of the Results

Chapter Five

Interpretation of the Results

Introduction

The last chapter of this study is devoted to the discussion and interpretation of the results of the three phases of the experiment; the questionnaire, the first analysis and the second analysis. The students' answers to the questionnaire will be presented and discussed in order to deduce the problems of their English learning at university. These problems will provide an overall vision of the difficulties that the students encounter with when using English.

After that, the errors detected from the students' scientific articles will be demonstrated, classified and explained. These errors will clarify and reveal the sources of the difficulties of the students with English and their linguistic weaknesses with writing scientific English, particularly writing scientific articles in English.

The second analysis, which took place after the lessons (described in the previous chapter), will be discussed to test the efficiency of the tutoring phase and find out if there are other areas of difficulty in the students' writings. The results of the second analysis will confirm or contradict the hypothesis of this study.

The study is also discussed given the limitations of the investigation in an attempt to enhance further research and suggest better work in the same area and topic. In addition to that, suggestions to improve a particular part of the English language teaching especially to non-native speakers are recommended on the basis of the implications of the study and the significance of the findings.

5.1. Results of the Main Questionnaire

The main purpose of the questionnaire is to identify the students' problems with scientific writing and tries to probe the major reasons of these problems and discover the students' needs from English in scientific contexts. It also highlights the students' problems with writing scientific articles as a particular type of scientific prose as the main area of interest in this investigation.

5.1.1. Presentation and Analysis of the Questionnaire

Below is the analysis of the students' answers to the questionnaire with tabulation, statistics and explanation. A descriptive and statistical method has been used in order to dig into the whys and wherefores of the students' problems.

Part One: Status of English in the Department of Chemistry (Q1-Q6)

Q.01. In which language did you have your studies at university?

Table 18. The Language of University Studies

Arabic	**French**	**English**	**Total**
00	13	00	13
00%	100%	00%	100%

As marked in the table, all the students (100%) had their entire university studies in French. It should be noted, however, that Arabic was occasionally used in cases that cannot be considered similar to the use and the dominance of the French language.

Q.02. Did you have English as separate module at university?

Table 19. The Presence of English in Science Departments

Yes	**No**	**Total**
13	00	13
100%	00%	100%

The students had their chemistry studies in French. However, this question intended to know whether they had studied English in any form at university (as a subject for instance). All the students said that they had English as an *extra* module taking into consideration that not all the students were in the same academic year (as stated earlier; 2012-2013 and 2013-2014).

Then, they were asked to specify “when exactly” they studied English. This question intended to know at which stage of their university studies they studied English (their under-graduation, Magistére phase or post-graduation). All of them said that they had English in under-graduation period, exactly the first or the second years (as freshmen or sophomores).

Question 02 continued to ask “**how much time was devoted to English**” as an extra subject. They mentioned that it was only one session per week which lasted only one hour and a half. Some of them added: “At that time we did not attend regularly”. They have also said that this module was for only one year in their university studies.

Q.03. What did you study in the English courses?

Table 20. The Content of the English Courses

Content	Occurrence
Grammar rules	03 (13.64%)
Vocabulary (terminology)	13 (59.09%)
Translation	04 (18.18%)
Writing	00 (00.00%)
Others	02 (09.09%)
Total	22 (100%)

The students were provided with multiple choices so that they can remember what they had and what they had not in the English lessons during their under-graduation studies. All the students remembered that they had *terminology* (13). Four of them added that they had some *translation* (from English to French) but even this translation was concerned with words only. Three said that they had some *grammar rules* but in general not with specific use in scientific contexts. Some of the students mentioned that one of these rules was about auxiliaries (to be and to have).

None of the students mentioned writing as part of their English studies in the past. This proves that these students did not have any previous training in writing at least at university.

It can be said that the focus of the English courses which they had at university was on *terminology* only. Even the other concepts were mainly around terminology. An exception might be the grammar rules, but like they said, general English. The other elements added by the students were few tenses such as the present simple and sentence structure which as a matter of fact are part of grammar rules.

Q.04. Have you dealt with scientific texts during these lessons (reading or writing)?

Table 21. Dealing with Scientific Texts

Yes	**No**	**Do not Remember**	**Total**
01	10	02	13
07.69%	76.93%	15.38%	100%

In order to know more about the content of the English course, the students were asked specifically about “scientific texts”. The majority of the students mentioned that they had not dealt at all with scientific texts, at least not with their teachers. Only one said s/he had seen texts with the teacher of English either to extract technical words or to translate some elements. However, two students answered this question neither with yes nor with no. Instead, they have written: “*I don’t remember*”. After all, they have passed their under-graduation stage few years ago.

Q.05. To what extent the English courses helped you learn the English you need?

Table 22. The Usefulness of the English Course

Very useful	**Somehow useful**	**Not at all useful**	**Total**
00	03	10	13
00%	23.07%	76.93%	100%

The purpose of this question is to see how the English course that they had at the pre-graduation stage helped them now in their post-graduation studies according to the students. All of them said that apart from learning some technical words (for those who answered "*somehow useful*"), they did not consider it nothing useful and when they reached this stage, they found themselves in need to learn English from the beginning. In other words, they wish they had gained some knowledge in English that could help them now.

Q.06. At the beginning of your studies, did you know that you would need to use English at this stage (post-graduation)?

Table 23. Students' Initial/Early Awareness of their Need to English

Yes	No	Total
00	13	13
00%	100%	100%

None of the students thought they would need English in their future studies when they were undergraduates. Two main reasons, as they have declared, were behind this unawareness. The first was the fact that at that time they did not know whether they would continue their studies in post-graduation stages or not. The second was their ignorance of the role of English in science study and communication. They thought that their future studies would be in French as they used to be.

Part Two: Students' Level, Interests and Difficulties in English

Q.07. What do you think your level in English is?

Table 24. Students' Level in English

Very good	Good	Average	Low	Very low	Total
00	01	04	07	01	13
00%	07.69%	30.77%	53.85%	07.69%	100%

One of these chemistry students has a good command of English. The rest of the students considered that their level is either *average* (30.77%) or *low* (53.85%). Only one thought that he had a *very low* level in English (07.69%). None of them considered that their level is *very good*. After they started dealing with English, reading or writing, they could recognise their level.

Q.08. Do you need English in your studies as post-graduates?

Table 25. Need English or not

Yes	No	Total
13	00	13
100%	00%	100%

The aim of this question was not to know whether they need English or they do not because their need for English is what created this whole work. The real interest was to know if these students were aware of the importance of English in their PhD studies, and if they know why they need it. That is why the question continued with "**what for exactly?**" in order to check their recognition of these needs and to make them state their needs from English using their own words.

Their answers can be classified into three major reasons. The first reason is *reading*; they stated that when they search for sources of information in their field of study, they find that almost all of them are written and published in English (only very few in a different language). The second is *writing*; they said: "In order to publish our findings (in this stage PhD), we have to write in English". The third reason is participating in conferences and study days and to pursue training stages abroad.

Q.09. Do you -usually- read in English?

Table 26. Students' Reading Habits

Yes	No	Total
13	00	13
100%	00%	100%

This question was asked in order to know the students' attitudes towards reading. Reading is considered an essential skill and a required tool in the path of science students. I addition, it is a useful skill in enhancing writing. For that reason, it was imperative to find out what they read and why exactly. Most of the students said that they read in their field of study only. Both their level and time did not allow them to read for pleasure. That is why the reasons they picked for reading were first, to get information in their area of interest, and second, to improve their English especially in writing scientific texts.

Q.10. When you read a text in your field of study (chemistry), do you fully understand it?

Table 27. Understandability of Scientific Texts

Yes	**No**	**Total**
1	12	13
7.69%	92.31%	100%

Reading for these students is not for pleasure, and thus, comprehension is important. Therefore, they were asked if they can easily read and understand a scientific text written in English. This question intends to reveal more about their level in English and see if they could relate this skill (reading) to their needs to write. The majority of them (92.31%) said that it was not easy to understand the whole text.

Q.11. What points do you find difficult?

Since reading is significant for these students and help them with writing their papers in one way or another, it is important to identify where exactly they find difficulties. These difficulties can be summarised in the following points:

- do not understand some words/expressions which they think affect the general meaning (technical or general);
- do not differentiate between the subject and the object in most complex sentences;
- do not understand the use of some words such as *since*, *while*, *when*, *that*, etc.; and,
- do not find the relationship between some units (sentences, paragraphs…).

Q.12. What do you do to understand the ideas of a text?

Table 28. Students' Techniques for Understanding

Techniques	Occurrence
-try to understand all the words	04 (14.28%)
-try to find the general idea of the sentence/passage	07 (25.00%)
-translate the text	10 (35.72%)
- use illustration (figures, schemas, …) to understand the text	02 (07.14%)
-Others	05 (17.86%)
Total	28 (100%)

The table above shows that the students have different ways and techniques they usually use to understand what they read. The most utilised one among them (35.72%) is translating the text (into French/Arabic) using Google Translate or similar applications. The second one in matter of use (25%) is that the students try to understand just the general idea of each unit instead of trying to understand every single word. The students mentioned some other techniques or tools including the use of dictionaries, the Internet or simply refer to someone who is "specialised in English".

Q.13. Did you have a training on how to read resources related to your studies in English?

Table 29. Trained to Read

Yes	No	Do not Remember	Total
00	12	01	13
00%	92.31%	07.69%	100%

Almost all the students (12 out of 13) said that they had not any training concerning how to read papers (resources of information; books, theses, articles, etc.) in English or how to understand it. This proves that they had not learnt reading comprehension tools or techniques in the course of English they had in earlier stages of their studies. Only one student said that s/he does not remember because -like it is mentioned before- it has been a long time since they had those courses.

Q.14. What do you do to improve your level in English?

The students found themselves in urgent need to use English. For that reason and no matter what their level is in English, they have to improve it in order to be able to write their papers and have direct access to the documents they read as well. This question which is open (no choices available) aimed to know how they would solve their problem with English.

Their answers were as follow:

- the Internet: all of them (13) considered it a useful source to learn;
- use dictionaries when reading and writing: most of them (08) thought it is the best way to use "correct" English;
- study in private schools of languages: some of them (03) found themselves obliged to have a training in English;
- use some language learning applications; and,
- look for a friend who may help in English only when it comes to writing their articles.

Q.15. Do you write in English?

Table 30. Students' Writing Habits

Yes	**No**	**Total**
13	00	13
100%	00%	100%

It was expected that all the students write in English. Writing is the main interest of this research. Question 15 actually intended to make sure that they write their papers by themselves regarding their level in English. The students were chosen because they are concerned with writing their papers in English; however, this question aims to confirm that they write in English because some students mentioned that they write in French and then look for translators.

Q.16. How often do you write in English?

Table 31. Frequency of Writing in English

Always	Often	Sometimes	Rarely	Never	Total
1	3	6	3	0	13
07.69%	23.08%	46.15%	23.08%	00%	100%

All the students write in English. However, they write with different frequencies. Only one *always* writes. Three of them *often* write and six said that they *sometimes* write. These students write not only their articles but other reports -even if they were not required tasks- in order to improve their writing. The last three *rarely* write because they write only their articles and that started only recently.

Q.17. When writing, do you have difficulties at the level of?

Table 32. Points of Difficulty in Writing in English

Points of Difficulty	Occurrence
Words	04 (10.26%)
Sentences	07 (17.95%)
Relationship between ideas	12 (30.77%)
Transition from one idea to another	10 (25.64%)
Others	06 (15.38%)
Total	39 (100%)

It appears from the table that the students' major problem was with the relationship between ideas (30.77%) as well as the transition from one idea to another (25.64%). Sentences in matter of simplicity and complexity also caused difficulties to the students when writing (17.95%). However, the students did not think that they had big problems concerning words (10.26%). The other points they added to the provided list were:

-starting sentences and paragraphs;

-conjugating verbs or tenses;

-explaining chemical items;

-using long formulas as parts of a sentence; and,

-writing introductions and conclusions.

Q.18. Do you think your level in English allows you to write -correctly-?

Table 33. The Level of Writing in English

Yes	**No**	**Total**
02	11	13
15.38%	84.62%	100%

A big majority of the students (84.62%) did not think that they can write "correctly" in English. They believed they needed assistance and guidance. Only two of them trusted their level and believed they can write by themselves. These two argued that their level in English and the strategies they usually apply allowed them to write.

Q.19. When you face a problem in writing in English, what do you do -usually-?

They were asked earlier about the techniques they used to understand what they read. This question intended to seek what techniques they employed to solve their problems with writing. It was also an open question in order to see how they exactly act in front of writing problems. Most of them said that they referred back to their supervisors. The Internet showed to be an important tool that the students overused or relied on in almost all their activities. Some of them declared that imitating other papers especially those published by their target journals was the most helpful way. Another method was translation. The students had good command of "scientific French" since they had all their university studies in French. For that reason, they used to write in French and then simply translated into English using some translation software and applications.

Q.20. According to your needs, the English course should contain.

Table 34. Content of the English Courses

Suggested Content	Occurrence
Grammar rules	08 (15.69%)
Vocabulary (terminology)	12 (23.53%)
Comprehension tools	09 (17.65%)
Translation	03 (05.88%)
Writing skills	13 (25.49%)
Others	06 (11.76%)
Total	51 (100%)

In order to know more about their needs from English, the students were asked what they would like to have in English courses, even though in this stage they would not have "regular" courses, at least not at university. All of them said that the *writing skill* must be part of the English lessons for all science students. Their second choice was *terminology* and then *comprehension tools* due to the importance of reading (as shown earlier). *Grammar rules* shared almost the same interest because of their importance in both reading and writing. Only few of them mentioned *translation*; maybe because they use it as a technique in understanding what they read and/or write (as stated above).

The students mentioned other concepts they thought they should have in the English courses. These concepts or points were as follow:

-explaining why they have to write in English;

-providing expressions that are frequently used in scientific texts;

-clarifying the specific features of scientific articles;

-presenting ways of translation from French into English;

-learning the reading skill; and,

-practising writing.

Part Three: The Scientific Article

Q.21. In your opinion, what is the importance of writing an article for science students?

All the questioned students are concerned with writing articles. This question aimed to test their awareness about the importance of writing articles in science. All of them agreed on the following reasons:

- to publish (share) the results of the scientific work;
- to mark the originality of their work;
- to persuade scientists that the presented work has gone through the right steps; and,
- to provide other scientists with data and information they can build upon in further works.

Q.22. Have you written Scientific Articles before?

Table 35. Writing Scientific Articles yet

Yes	**No**	**Total**
10	03	13
76.92%	23.08%	100%

Most of the students (76.92%) have written scientific articles before. The other three students have already started writing articles but they felt they are not good enough or considered them as "attempts only". It can be said that all the students at least had written drafts of SA.

Then, they were asked in what language they have written their articles in order to confirm that they are writing in English not in another language which was approved by their answers.

Q.23. Have you got any training on how to write Scientific Articles in English?

Table 36. Trained to Write Scientific Articles

Yes	**No**	**Total**
00	13	13
00%	100%	100%

All the students declared that they had not got any training on how to write scientific articles in English at university or even outside university. This might be due to the fact that the English courses took place in a stage when they did not have to write scientific articles.

Q.24. Did you get / ask for help to write your article?

Table 37. Getting Help with Writing Articles

Yes	No	Total
11	02	13
84.62%	15.38%	100%

The students' first meeting with writing scientific articles was difficult for them because they were not trained to write them before. They were instructed to communicate their work through scientific articles. That is why, most of them asked for help from their supervisors and teachers. The others refused to ask for help arguing that "it is easy to imitate already published articles following the same titles and steps".

Q.25. What format (layout) do you follow in your article?

As shown in a previous part of this research, the layout of the scientific article is of a paramount importance. For that reason, the students were asked about the format they have followed or usually follow in writing their articles.

All of the students answered that "it depends on the instructions of the journal that we aimed to publish in". Some of them added that they are familiar with the IMRaD format and that they have recognised it in several articles they have read. Some others have said that unawareness of the format is one reason why they were afraid of writing articles.

Q.26. Do you know the IMRaD format?

Table 38. Awareness of the IMRaD Format

Yes	No	Total
09	04	13
69.23%	30.77%	100%

This format is thought of as the most frequently used one among many available formats. The IMRaD format is so considered because it comprises the sections that “parallel the experimental process” (Lewiston, 2011, p. 2). It has been chosen because it easily displays the main components of the article and other formats differ only in the order of these components. This question intended to test and direct their awareness to this format and most importantly to the components of the scientific article.

Some of the students (30.77%) did not know this format at all. They might have seen it but they were not aware what it was or why they should consider it or use it. These students were not aware of the existence of a layout to follow when writing SA. They argued that “the titles and sub-titles depend on their work”.

Those who knew the IMRaD format before (69.23%) -when asked how they knew it- mentioned two main sources. The first was that their supervisors recommended this layout. The second was the targeted journals where they have checked for specific instructions about the shape and order of sections.

Q.27. In what order do you write your Scientific Article (during the writing process)?

Table 39. Order of the Sections When Writing

Order	Abstract	Introduction	Methods and Materials	Results	Discussion	Conclusion
First	2	3	4	4	0	0
Second	0	2	5	4	2	0
Third	0	1	4	3	5	0
Forth	0	7	0	2	4	0
Fifth	8	0	0	0	2	3
Sixth	3	0	0	0	0	10

The table above summarises the order of the sections of the article according to the students’ choice to start writing with. The *Introduction* was preferred to be written **forth** while the *Abstract* was rather the **fifth**. The *Materials and Methods* section was written **second**, **first** or **third**. The *Results* were written **first**, **second** or **third** mostly. The

Discussion came **third** or **fourth**. Concerning the *Conclusion*, it was the last part to be written as most of the students (10 out of 13) had stated.

After that, the students were asked to justify their order. There were different reasons for the several choices the students made. One of the answers was that the students followed the order of the sections in which they appear in the article. They justified that it was "logical that what comes first should be written first". Another choice was starting with description of the methodology used and then statement of the results and their discussion, explaining that they "write them in parallel to laboratory experiments". A similar order was to state the findings, discuss them and then describe the methodology. These two choices were due to the fact that the most important parts of the article are these three sections: Methodology, Results and Discussion. Another mentioned reason was the fact that the Abstract, Introduction and Conclusion cannot be written before the results are stated and discussed.

Q.28. What difficulties do you face when writing Scientific Articles?

This question is quite important and direct to the required purpose of the questionnaire which is identifying students' difficulties with scientific article writing. Similar to previous questions, suggestions were not provided for this question in order to let the students express and explain their main difficulties and weaknesses.

The first difficulty they mentioned was "writing in English". The change in the language for the students -from French to English- created a problem for them when writing. The second difficulty (which might be related to the first) was their level in English. The majority of the students said that their level did not allow them to write even those who thought their level was good. Another problem was lack of training; as they said: "we were not taught how to write". The content of the English lessons they previously had were not sufficient. Their unawareness and lack of knowledge about this type of paper -shape and way of writing- also considered to be a big problem for them.

Q.29. Do you think a scientific article can be rejected (by the journal you submit to) only because of language-related mistakes?

Table 40. Awareness about Language Impact on the Acceptability of Articles

Yes	**No**	**Do not know**	**Total**
09	02	02	13
69.24%	15.38%	15.38%	100%

Most of the students (69.24%) recognised the importance of a good, correct language in the acceptance and publication of scientific articles. The rest of them thought that content is what matters and language cannot affect the work. (The researcher assumes that these students have not yet experienced publishing an article).

Q.30. What do you suggest to make the English courses more effective and useful for science students in the future?

Even though the students will not have English courses in the future; at least not at university; this question intended to let the students reveal more of their needs from English which is of a twofold purpose. The first purpose is to help improve the way English is taught in science departments in Algerian universities. The second is to thoroughly prepare the lessons for the students which is the next step in this research.

The students at this stage composed an -overall- idea about their needs from English. Therefore, they have suggested the following points to make the English courses more effective:

Table 41. Suggestions to Improve the English Courses

Students' Suggestions	Occurrence
-Clarify the nature, content and layout of scientific articles	13 (17.34%)
-Teach the basics of English	12 (16.00%)
-Devote more time for English (more than one session per week)	10 (13.33%)
-Deal with sample articles: reading comprehension	10 (13.33%)
-Improve reading and writing skills	08 (10.66%)
-Practise writing articles	08 (10.66%)
-Teach grammar rules which are more frequent in scientific context	06 (08.00%)
-Teach English every year to provide all important detail and improve learners' levels.	04 (05.34%)
-Deal more with scientific and technical texts	03 (04.00%)
-Provide up-dates in scientific English	01 (01.34%)
Total	75 (100%)

All the students (100%) believed that the English courses should first and foremost contain sufficient details about the scientific articles. Their second suggestion was to have the basics of English since they need it on the one hand, and their level does not allow to have scientific English directly without having some basic knowledge in general English on the other. They have also suggested to devote more time to English (more than one session per week) and teach it every year to provide all important detail and improve learners' levels since it turns to be important in their studies. A similar frequent suggestion was also about articles which was mainly reading and understanding them.

Some of the students thought that the best content which should be presented in the English courses was how to write a scientific article. It is -for them- the most important skill to learn. Nevertheless, this skill requires a bit of each of the previous points.

There were some other suggestions that are not far from the aforementioned ones with a bit of precision. For example, they recommended to have the frequent grammar rules in scientific context rather than general rules. They have also suggested to deal with scientific and technical texts rather than just terminology. In addition, they would like to be informed with up-dates in scientific English if any.

5.1.2. Discussion and Summary of the Findings

Analysing the students' questionnaire provided a general view on their difficulties and needs with scientific English. Understanding those problems and requirements help designing the next step of the treatment chosen in this work; lessons.

5.1.2.1. The Status of English in Science Departments in the Algerian University

English did not take the right position in science departments in Algeria. It was not considered of any significance since the main language used was French (and occasionally Arabic) and thus it was only taught as an extra/secondary module. It was not even taught every year; only in the first year for most students. The time devoted did not exceed an hour and a half per week which did not allow to have enough, required content.

The focus of these few sessions was mainly vocabulary; precisely terminology (technical words). Neither teachers nor students considered that there was a more important content to be presented. The reasons behind this insufficient content of English courses can be summarised in two main points. The first point is lack of knowledge about EST even among teachers of English (at that time); EST and the need for English in science communication has not been a shared concept in previous years (it was only recently that this part of ELT has become known and required). The second is the students' unawareness of the need for English in future stages, not knowing that they might proceed in further stages of their studies, and thinking that they would continue studying in French as they used to do.

5.1.2.2. Students' Level

The students' level in English is considered low (below average) with a percentage of 61.54%. It did not allow them to write (nor to read) scientific English. This can be justified with the following reasons:

- It is a foreign language.
- They have had their studies in French.
- They had no previous interest in English.
- They were ignorant of the importance of English in communicating science.
- When they discovered their need for English, they could not decide on a suitable way of learning English to adopt.
- The difficulty to devote time regarding their –scientific- activities.

The students, however, did not stand idly and tried to improve their level since English became an important part of their academic life. They have followed different ways to beat their weaknesses (learning general English, looking for help, using the internet, translating, etc.). Yet, these ways were insufficient because they did not know what and how to learn exactly (GE instead of EST).

5.1.2.3. Students' Needs and Requirements

The students' main interests in English can be summarised in three major points and all are related to their academic requirements: (1) reading documents in their field of study, (2) writing articles describing their scientific work and (3) participating in seminars in written or spoken form. Even though they had stated their needs, it was not enough for them to know what to do exactly in order to fulfil these interests and needs.

Additionally, students were unfamiliar with EST and the speciality of scientific discourse in English, and did not know how to start learning or using the language. They were using random techniques to accomplish their instant prerequisites (read, understand, analyse).

5.1.2.3.1. The Reading Skill

Reading makes a crucial skill in the academic life of these students. As PhD science students, researchers and future scientists, they are supposed to be updated with new publications in their field of specialty -mainly journal articles- which are mostly available in English. Therefore, reading is a must-have skill every student should master. This kind of reading is not similar to reading for pleasure (novels, books, etc.); it requires understanding, analysing, evaluating, questioning, etc. As stated by Raff (2016), “getting science wrong has very real consequences. But journal articles, [how science is communicated] are a different format to newspaper articles or blogs and require a level of skill and undoubtedly a greater amount of patience”.

The students were aware of the importance of the reading skill. All of them read in English and most of them read articles related to their work and study, in order to gather the knowledge they require and generate a sufficient amount of information on articles that may help them in writing theirs.

Despite this awareness and practice, the majority of the students did not understand what they read (92.31%). They used to find difficulties at the level of words, expressions and transition between ideas and paragraphs. In order to overcome these difficulties, they translate the text into French or Arabic, try to understand all the words in the text or comprehend the general idea of each passage.

5.1.2.3.2. The Writing Skill

Writing is the students’ biggest problem and their main interest. They are concerned with writing journal articles in English but writing science in English is not an easy task. Their most difficulties were in forming complex sentences, connect ideas, choosing the correct tense and writing introductions and conclusions.

As in reading, the students followed some strategies to overcome their writing weaknesses. The first of these strategies was to ask for their supervisors' guidance. The second one was imitating articles published in the same domain as theirs and usually by the same target journals. The other strategies were using the Internet and writing sites or writing in French and then translating into English.

5.1.2.4. The Scientific Article

Writing scientific articles (journal articles) is the chief interest of these students. They are aware of the importance of writing articles in their studies and career. All of them had -at least- tried to write articles despite the fact that they had not got any training on how to write them.

Their major problems with writing articles can be summarised in their ignorance of:

- what to start with;
- how to write each part;
- what kind of information should be included in each section;
- how to write introductions and conclusions;
- what criteria to follow in order to write a good title and abstract;
- how to decide on the key words to be mentioned; and,
- the specific use of English in science communication.

5.1.2.5. The Content of the English Course

After discovering and understanding their needs, the students suggested to improve the English course at university for future generations. The major stated points were mostly around the writing and reading skills, the language and form of the scientific article, grammar and vocabulary. Both theory and practice were seen to be important in the lessons in order to improve students' level and enhance their performance in reading documents and writing articles.

They have also pointed to the insufficient time devoted to English with regard to its importance in their studies and career. One session per week and in one or two academic years is not enough. They proposed to teach English every year so as to present all essential details referring to their needs and enhance their level in scientific English.

All in all, the data obtained from the students' responses to the questionnaire revealed the following insights on students' level, requirements and weaknesses:

- The students' needs for English boils down to: reading documents and writing articles, both in their field of interest.
- They were aware of their weaknesses and recognised their difficulties which appeared in declaring their level to be low and below average, stating their problems with understanding what they read and expressing their weakness with writing and communicating science.
- Another problem they confronted with was the lack of ability and guidance on how to overcome the weaknesses and difficulties mentioned above. They were confused about the ways they had to adopt to learn the English they needed.
- Their low level in GE in addition to their unfamiliarity with EST and the specific characteristics of the scientific discourse added to this confusion. The students were searching for ways to learn GE instead of EST which consumed time and efforts and prevented them from meeting their needs.
- Their answers, also, clarified the image of how English is presented and dealt with in science departments (in the recent past) which was found to be far from what is really required and necessary. Therefore, the way English is taught for these students must be revised and adapted in order to meet students' needs in these fields.

5.2. The First Analysis: Results and Discussion

The first analysis was made to articles written by the students in question. The condition of this set of articles was not to be examined or corrected before (drafts). The purpose of this analysis is to get an in-depth understanding of the students' weaknesses and difficulties with writing English for science.

It aimed to get a deep insight on students' difficulties and weaknesses when it comes to English. The errors were spotted and analysed in order to understand what points of the language use those students had problems with. The clearer the problem is, the easier the solution is to be systemised and beneficial.

The detected errors from students' papers were gathered and classified into three major types: grammatical, lexical and stylistic. The following table displays numbers and percentages of these errors:

Table 42. Types of Errors

Type of Errors	Frequency of Errors
Grammatical	3426 (54.20%)
Lexical	2051 (32.45%)
Stylistic	844 (13.35%)
Total	6321 (100%)

Grammatical errors were more numerous than errors related to lexis and style with a percentage of 54.20%. This result can be referred to lack of -sufficient- learning and acquiring grammar rules and/or their application. One of their writing strategies was to imitate already published articles (in their target journals) which means they did not pay attention to certain details taking into consideration that these published articles are not free of mistakes.

Lexical errors came in the second place with a percentage of 32.45%. It reveals that the second problem of students is using words correctly and appropriately. Students showed that their primary knowledge of words is around technical and some ordinary words only. Problems of word usage occurred at the level of the part of speech and word choice which indicated again lack of knowledge of language rules.

Stylistic errors (13.35%) refer to errors related to the employment of stylistics features that are not encouraged in scientific discourse (as shown in previous parts of this paper) such as personal language, ambiguity and value judgement. Again, unawareness and shortage in learning are the main causes of such errors. Lack of revision and the status of English to these students are also possible reasons. In addition, style in scientific context differs from that in other registers. These errors might also be the result of misrepresentation of the intended meaning after translating their own texts from Arabic or French.

5.2.1. Grammatical Errors

Grammatical errors refer to the violation of grammar rules whether it is wrong employment, incomplete application or total ignorance of them. Those errors were categorised into two types: errors at the level of the sentence; and errors related to the verb. Each type is divided into several categories as shown in table 43 below:

Table 43. Categories of Grammatical Errors

Category of Errors	Sub-category	Frequency	Total Percentage
Sentence	Sentence structure	1124 (32.81%)	70.58%
	Subject-verb agreement	527 (15.38%)	
	Punctuation	452 (13.19%)	
	Active-passive structure	315 (09.20%)	
Verb	Tense	811 (23.67%)	29.42%
	Modal use	79 (02.30%)	
	If-conditional tenses	65 (01.90%)	
	Phrasal verbs	53 (01.55%)	
	Total	3426	100%

5.2.1.1. Sentence Errors

Errors at the level of the sentence are the highest occurring ones with a percentage of 70.58%. Sentence errors are due to a lack of understanding of how to form a correct sentence in English (flow and unity of a sentence, balance, components, and punctuation); and a lack of knowledge of the role of the sentence (communicates one complete thought/idea). This is caused by their low level in English (most of them) and lack of understanding of grammar rules. They are sometimes due to a lack of care when writing; the students simply write their ideas caring more about the content than the sentence and so, they produce erroneous sentences simply by putting the necessary words together to form ideas arguing that “words can transmit the message”.

5.2.1.1.1. Sentence Structure

The most frequent sentence errors (32.81%) are those at the level of sentence structure. In this type of errors, two main problems can be distinguished in the students’ errors: long sentences and unfinished sentences.

A long sentence -also known as a run-on sentence- usually refer to combinations of independent clauses that are not linked in a grammatically correct way, i.e., neither with correct punctuations nor with appropriate conjunctions. This kind of sentences was frequent in the Methods section of the students’ papers where experiments were described and most ideas were related which caused them to write run-ons. A long sentence can be corrected with one of three different techniques: adding a semicolon, using an appropriate conjunction or cutting it into two separate sentences.

Note: The sentences in the examples were corrected with reference to the sentence that preceded them or to the student’s intended meaning. (X is for errors and √ is for corrected utterances)

Examples:

X *The optimized geometry, its orbitals and ~~**of**~~ Mulliken charges were visualized using Avogadro program the molecular electrostatic surface potential (MESP) was plotted by Jmol program[12].*

- ✓ *The optimized geometry, its orbitals* ***and*** *Mulliken charges were visualized using Avogadro program**. T**he molecular electrostatic surface potential (MESP) was plotted by* ***the*** *Jmol program[12].*

✓ *Several modifications on the RP equation have been made to include chemical reactions, mass and heat transfer, radiation energy, etc. [28–30] but this research group has recently established a simple model that provides reference results in sonochemistry, i.e., estimation of the bubble temperature using HO^- as a probe, interpretation of the effects of gases, frequency, acoustic power, liquid temperature on the sonochemical reaction, prediction of the active bubble population in acoustic cavitation field at different conditions, illustration of the mechanism of the sonochemical production of hydrogen, etc.*

- ✓ *Several modifications on the RP equation have been made to include chemical reactions, mass and heat transfer, radiation energy, etc. [28–30]**. However,** this research group has recently established a simple model that provides reference results in sonochemistry, i.e., estimation of the bubble temperature using HO^- as a probe, interpretation of the effects of gases, frequency, acoustic power, liquid temperature* ***in*** *the sonochemical reaction, prediction of the active bubble population in acoustic cavitation field at different conditions, illustration of the mechanism of the sonochemical production of hydrogen, etc.*

✓ *Calculations were performed using the VASP [15–17] code based on the density functional theory (DFT) [18,19] ultrasoft Vanderbilt type pseudopotentials [20] were* *used to describe the interactions between ions and electrons~~,~~ the generalized gradient approximation (GGAPW91) of Perdew et al. [21] was applied to evaluate the exchange–correlation energies of all examined structures.*

- ✓ *Calculations were performed using the VASP [15–17] code based on the density functional theory (DFT) [18,19]**. U**ltrasoft Vanderbilt type pseudopotentials [20] were used to describe the interactions between ions and electrons**. T**he generalized gradient approximation (GGAPW91) of Perdew et al. [21] was applied to evaluate the exchange–correlation energies of all examined structures.*

An incomplete sentence (or sentence fragment) is a group of words that do not form a complete correct sentence but stand on its own. Sentence fragments appeared in several cases in the analysed papers: a subject only (a noun phrase); a subordinate/dependent clause (starting with subordinating conjunctions: *while, if, because, though, but, and, etc.*); a prepositional phrase (*of, in, at, etc.*) or a sentence without the main verb.

Examples:

- X *Therefore DS (17.4% of α-pinene and 8.9% of β-pinene) the essential oil **~~that~~** was able to inhibit all the microorganisms tested with MIC values ranging from 16 µg/mL to 40 µg/mL.*
  - ✓ *Therefore, DS (17.4% of α-pinene and 8.9% of β-pinene) the essential oil was able to inhibit all the microorganisms tested with MIC values ranging from 16 µg/mL to 40 µg/mL.*
- X *The main components of the essential oils **~~which~~** were: α-pinene, β-pinene, α-phellandrene, fenchylacetate, elixene, aristolene, caryophyllene oxide and carotol.*
  - ✓ *The main components of the essential oils were: α-pinene, β-pinene, α-phellandrene, fenchylacetate, elixene, aristolene, caryophyllene oxide and carotol.*

X ~~***Because of***~~ *their low thermal conductivity of ceramic layer and thermal diffusivity combined with a good chemical stability at high temperature.*

✓ ***The choice of the ceramic layer is due to its*** *low thermal conductivity and thermal diffusivity combined with a high chemical stability at high temperature.*

X ~~***While***~~ *these essential oils inhibited the growth of both the gram-positive and gram-negative bacteria at MIC values ranging between 16 µg/mL and 80 µg/mL.*

✓ *These essential oils inhibited the growth of both the gram-positive and gram-negative bacteria at MIC values ranging between 16 µg/mL and 80 µg/mL.*

X *By comparing the numerical and experimental results obtained on an alloy models.*

✓ ***A modal can be made*** *by comparing the numerical and experimental results obtained on an alloy model.*

X *The bacterial pathogens including food spoilage bacteria Pseudomonas aeruginosa ATCC 27853, and food-borne pathogens namely, Enterobacter aerogenes, Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 43300.*

✓ ***The reference strains of*** *the bacterial pathogens including food spoilage bacteria Pseudomonas aeruginosa ATCC 27853, and food-borne pathogens namely, Enterobacter aerogenes, Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 43300* ***were taken from Pasteur Institute (Algiers).***

5.2.1.1.2. Subject-verb Agreement

The second common error in sentence errors is subject-verb disagreement (15.38%). In English, the subject and the verb must agree in number. The problem of disagreement appeared repeatedly with the present simple tense (the presence or the absence of third person -s) and the auxiliaries (be, have and do). The cases found in the papers were several; among them:

1. Plural subject with a singular verb or vice versa;

- *The MESP is a plot which* ~~***evaluate***~~ ***evaluates*** *the outer regions …*
- *The growth of the oxide layer (currently after some hours of working)* ~~***change***~~ ***changes*** *the behavior of the thermal barrier system.*
- *This ratio* ~~***reach***~~ ***reaches*** *a maximum of 23‰.*
- *the adherence and stress in the layer* ~~***is***~~ ***are*** *important to understand …*

2. The verb *to be* after *'there'* which is determined by what comes after;

- *There* ~~***was***~~ ***were*** *not enough* *data.* (the word *data* is plural)

3. Long confusing subject: distance between the subject and the verb, that includes modifying phrases, comes between the subject and the verb, and this makes the writer loses track of the main subject. In some cases, the main subject is singular and the additional parts that come directly before the verb are plural which causes confusion.

- *The chemical composition of roots and aerial parts extracts of this species* ~~***have***~~ ***has*** *been studied previously.*

4. Ignorance of some plural words such as *data* and *spectra*;

- *The experimental data* ~~***was***~~ ***were*** *analysed by the Langmuir and Freundlich isotherm models.*

5. Subjects including conjunctions "and, or".

- *The variation of the bubble temperature and the amount of the trapped water vapor as function of liquid temperature* ~~***shows***~~ ***show*** *an opposite trend.*
- *Increasing acoustic power and decreasing frequency* ~~***increases***~~ ***increase*** *the production of free radicals.*
- *Their extraction, concentration, or the selection of varieties with high content of flavonoids* ~~***allow***~~ ***allows*** *manufacturers.*

5.2.1.1.3. Punctuation Errors

Punctuation errors are numerous because of students’ deficiency of knowledge and training of punctuation use. The most occurring punctuation marks in the students’ papers are the full stop and the comma. Their errors were in fact in the use of these punctuation marks in particular whether addition or omission.

The most existing error was the addition of the comma between the subject and the verb especially when the subject is considerably long. The students argued that since the subject is too long containing many parts, it should be separated from the verb in order not to confuse readers, for instance:

- *The 1,3-dipolar cycloaddition reaction between the substituted α-alkoxynitrones (1) and ethyl vinyl ether (2), leads to the ortho product.*
- *The geometries of transition states (TS) for these reactions, have been calculated.*
- *It means that the thermal barrier system spallation, starts with the pull of the outer layer.*
- *The use of PHREEQC software (USGS), has allowed …*
- *A QSAR study of 24 flavonoids and derivatives, was performed …*
- *Quantum chemistry calculations at DFT/B3LYP scale, had been used.*

Another frequent error was the omission of the full stop at the end of sentences. This could be due to lack of care or forgetting which might be considered mistake not error. This omission of full stops usually occurs when the sentence ends with a numeral, a chemical symbol or a reference number in square brackets (which is quite common in their papers). A similar committed error, which can be considered a mistake, was with capital letters; students had mistakenly forgotten to capitalise some of the initial letters at the beginning of new sentences or erroneously capitalised ordinary words to give it emphasis (*in Scheme 1, in Table 2, the produced Solution, the presence of Forty four compounds, All*

The tested samples …); or capitalise the first word after a semicolon (*materials; The major* …).

The students, unaware of the fact that English and French use punctuation marks in numbers oppositely, they use the comma instead of full stop (point) in decimal numbers (for example: the pi number (π) in English is approximately equal to 3.14 and in French is 3,14). In English, the full stop is used in decimal numbers and the comma is used to separate three digits in normal numbers; however, in French, it is the other way around (1.000 is one thousand in French and only one in English).

Some other punctuation marks were misused, such as the three-dot ellipsis (… or sometimes more) at the end of lists which is better substituted with "***etc.***". In addition, the absence of commas -before and- after link words like "therefore, thus, furthermore, etc." (*The goal therefore is to develop* …).

The last detected punctuation error is the wrong use of parentheses. Parentheses ( ) are used to enclose supplemental information in a sentence which their omission do not affect the sentence grammatically. However, these students used them to enclose necessary information and important parts of the sentence especially when they indicated numbers or symbols; for instance, "*The (MESP) is a plot …*".

5.2.1.1.4. Active-passive Structure

The errors related to active-passive sentences are about the passive-sentence structure and appropriateness (whether it should be active or passive). Concerning the structure, passive sentences appeared to have three problems: no or wrong *to be* in the verb form, basic verb form instead of the past participle or no *by* before the agent.

Examples:

X These parameters calculated by equations 10 and 11 below.

- ✓ These parameters ***were*** calculated by equations 10 and 11 below.

- X The electronic structures of stationary points ***~~was~~*** analysed the natural bond orbital (NBO) method.
  - ✓ The electronic structures of stationary points ***were*** analysed ***by*** the natural bond orbital (NBO) method.
- X All calculations ***~~have~~*** carried out using the Gaussian 09 release package.
  - ✓ All calculations ***were*** carried out using the Gaussian 09 release package.
- X All the structures were ***~~characterize~~*** by vibrational analysis in the harmonic approximation.
  - ✓ All the structures were ***characterized*** by vibrational analysis in the harmonic approximation.

Concerning appropriateness, students failed to choose the right voice in some cases. This failure was mainly about employing the passive voice with an attempt to sound more scientific or more objective; i.e., use it for the wrong purposes. The main reason behind this error is their erroneous thinking that science is better communicated with passive voice; and so, it was excessively used.

Thus, the passive voice was improperly used instead of the active voice. In some cases, the verb form was incorrectly in the passive where it was not clear which part acted the verb and which was acted upon.

- X The ***~~results was agreed~~*** with early reports [22-24].
  - ✓ The ***results agree*** with early reports [22-24].
- X The LUMO of 1a and the HOMO 1b ***~~were~~*** reacted to produce C1 carbon and C7 carbon.
  - ✓ The LUMO of 1a and the HOMO 1b reacted to produce C1 carbon and C7 carbon.

(Passive is not supported here because chemicals react and are not being reacted).

In some other cases, the passive is more appropriate and preferred to active so as to avoid personal language.

X ***We carried out*** density functional theory calculations using B3LYP method.

✓ Density functional theory calculations ***were carried out*** using the B3LYP method.

5.2.1.2. Verb Form Errors

The second type of grammatical errors is related to the verb form (with a percentage of 29.42%). Students committed errors about the verb form in tense use, auxiliary and modal use, infinitive, and phrasal verbs. These errors are due to lack of practice since these students are using English to write about their findings and did not learn details about grammar rules or practise each rule and its use or its exceptions. Rules related to the areas where the errors mostly occur require thorough study and enough practice to be used correctly each time.

5.2.1.2.1. Tense Errors

Tenses need to be mastered through learning form and use in order to have correct communication. The most occurring tenses in scientific writing (and these papers in particular) are: the present simple, past simple, present perfect and future simple. The nature of information being communicated is what determines the appropriate tense to be selected. For instance, recommendations and previous work are not to be communicated in the same tense.

Errors committed in tense use are the most frequent in this category (23.67%) and comes second in all grammatical errors. These errors are related to all verb forms and uses (apart from subject-verb disagreement which is dealt with as sentence error) including: wrong verb form, inappropriate position of the verb, incorrect use of the infinitive, auxiliary and negative form, omission or addition of verb and irregular verbs in past simple and past participle.

Examples:

- X The MS ~~***working***~~ in electron impact mode at 70 eV; electron multiplier, 2500 V; ion source 280 and 300°C respectively.
  - ✓ The MS ***works*** in electron impact mode at 70 eV; electron multiplier, 2500 V; ion source 280 and 300°C, respectively.
- X It shows where ~~***could be***~~ electrophilic or nucleophilic attacks.
  - ✓ It shows where electrophilic or nucleophilic attacks ***could be***.
- X The continuous oxygen content ~~***to decrease***~~ by the upstream towards the downstream.
  - ✓ The continuous oxygen content ***decreases*** by the upstream towards the downstream.

Or:

- ✓ The oxygen content ***continues to decrease*** by the upstream towards the downstream.

- X However, they did not ~~***enabled***~~ them to resist the thermal loadings.
  - ✓ However, they did not ***enable*** them to resist the thermal loadings.
- X Climate is characterized by the annual temperature mean ~~***is***~~ of +16°C.
  - ✓ Climate is characterized by the annual temperature mean of +16°C.
- X The mesh generation ~~***done***~~ automatically with two forms of nodes.
  - ✓ The mesh generation ***was done*** automatically with two forms of nodes.
- X This information ~~***is cross***~~ with previous researches.
  - ✓ This information ***is crossed*** with previous researches.
- X The calculations ~~***are showed***~~ in the following table.
  - ✓ The calculations ***are shown*** in the following table.
- X The computational method ~~***costed***~~ less money and time than experimental methods.
  - ✓ The computational method ***cost*** less money and time than experimental methods.

X An addition of 0.1 of the alkane ***~~has leads~~*** to totally different results.

✓ An addition of 0.1 of the alkane ***has led*** to totally different results.

Tense errors also include inconsistency of tense use; i.e., the use of several tenses in one clause, sentence or paragraph where all actions took place in the same time. The role of tenses does not only lie in the idea of expressing time and order of events, but also in the fact that incorrect tense use might change meaning completely. For instance, the use of the future tense in describing the methods used in the experiment is misleading and might be interpreted that the methods were not actually applied in this research.

X Currently, the composite system, such as a brittle coating on a tough substrate, ***~~will~~*** respond to bending differently. When the strain in the upper fiber of the sample in the coating *reached* the value of crack nucleation, a crack *was* formed in the coating.

✓ Currently, the composite system, such as a brittle coating on a tough substrate, ***responded*** to bending differently. When the strain in the upper fiber of the sample in the coating *reached* the value of crack nucleation, a crack *was* formed in the coating.

X It is then concluded that in different solvents the carbon C17 of nitrone (**1b**) *would favour* an interaction with the carbon C11 of the ethyl vinyl ether (**2**), while its oxygen O2 ***~~interact~~*** with the carbon C1 of reactant (**2**).

✓ It is then concluded that in different solvents the carbon C17 of nitrone (**1b**) *would favour* an interaction with the carbon C11 of the ethyl vinyl ether (**2**), while its oxygen O2 ***would interact*** with the carbon C1 of reactant (**2**).

X An Excel worksheet was used, the input data ***~~are~~*** classified.

✓ An Excel worksheet was used; the input data ***were*** classified.

Speaking of consistency of tense use, most students failed to apply the appropriate tense(s) in each section. In other words, the students did not recognise and respect the fact that the nature of information, which differs from one section to another in the scientific article, determines the choice of tense(s) to be used. The errors spotted in this vein are summarised in the following table:

Table 44. Students' Wrong Choice of Tenses within Sections of SA

Section	Students' Choice	Appropriate Tense
Abstract	Present simple (only)	Past tenses Present simple
Introduction	Present simple (only) Past simple (only)	Past tenses Present simple
Methods and Materials	Present perfect, present simple and past simple	Past tenses
Results	Present simple (only)	Present simple Past tenses
Discussion	Present simple or past simple	Present simple Past tenses
Conclusion	Present perfect, present simple and past simple	Present simple Future

A similar error is *faulty parallelism* (parallel structure) in one sentence where two verbs (or more) have the same subject and joined with conjunctions (and, or) but are not conjugated in the same tense for wrong past form of irregular verbs particularly (It is dealt with as verb error not sentence structure or stylistic error in order to explain it well to students). For example:

X Researchers had used this method previously and ~~***got***~~ the results summarised in table 6 below.

✓ Researchers had used this method previously and ***gotten*** the results summarised in table 6 below.

Moreover, some noticed errors concerning incorrect tense was with some time expressions. Since, for, ago and previously are some instances; in some cases, the use of these words is incorrect. This error is also caused by lack of knowledge about these words in particular.

X This herbicide ~~***is***~~ widely used in agriculture to control the growth of grass and weeds in cereal, vegetable and fruit tree crops since more than 40 years ~~***ago***~~.

- ✓ This herbicide ***has been*** widely used in agriculture to control the growth of grass and weeds in cereal, vegetable and fruit tree crops ***since*** more than 40 years.

Another observed error was the use of only one tense all over the paper (present simple).

5.2.1.2.2. Modal Use Errors

The most noticed error with modal use was not with their meaning but with the verb that comes after. They -against the rule which says that only the base form of verbs is put after modals- conjugated the verb in present simple (adding -s) or past simple. In addition to that, the modal verb *must* is erroneously used with the preposition "to" imitating other modal verbs with similar meanings such as *have to, ought to, need to,* etc.

Examples:

- The compound *should* ***~~has~~*** ***have*** a considerable ductility.
- An acid *can* ***~~makes~~*** ***make*** it possible.
- A solute *can* ***~~results~~*** ***result*** in an oxidation process
- Both ways *should* ***~~considered~~*** ***consider*** developing new TBC structures.
- None of the proposed mechanisms *can* ***~~have been~~*** ***be*** generalized to all the previously discussed work.
- where the researcher *must* ***~~better known~~*** ***know*** the products handled by exploiting their material safety data sheets and calculating the various parameters of green chemistry.
- the QSAR method *must* ***~~to~~*** ***be*** tested using all the given calculations.

5.2.1.2.3. If-conditional Tenses

This category was separated from tense errors in order to highlight the if-conditional incorrect use and draw students' attention to its appropriate forms. Expressing condition is expected in scientific papers and sometimes necessary to state what is tested under certain conditions. As a matter of fact, the students were familiar with this use of "if-conditional". However, they were not aware that it has strict rules when it comes to verb tenses. Therefore, the detected problem was not with the use of *if* but with the tenses of the verbs expressing both the condition and the result.

- X If the reaction *were* complete compared to the quantity of limiting reagent, the yield *will be* equal to 1.
  - ✓ If the reaction were complete compared to the quantity of limiting reagent, the yield **would be** equal to 1.

Or:

  - ✓ If the reaction **is** complete compared to the quantity of limiting reagent, the yield will be equal to 1.

In some cases, the conditional was unsuitably used while the sentence expresses another meaning (concession for instance) as in the example below:

- X If green chemistry principles and technologies *have recently made* their ways in chemistry classroom pedagogy in several universities in the world [10], this *is* not the case in Algeria.
  - X The principles and technologies of green chemistry have recently made their way in chemistry classroom pedagogy in several universities in the world [10]; *however,* this is not the case in Algeria.

5.2.1.2.4. Phrasal Verbs

The errors related to phrasal verbs are usually with the particle (adverbial) which comes after the verb (the adverb or preposition). Students failed to choose the right adverbial because they used to translate the intended meaning from Arabic or French or simply used the preposition or adverb they thought convenient for the action expressed. Therefore, the most occurring adverbials in phrasal verbs mentioned by them were: *for*, *in*, *on* and *at*. The adverbials of their choice happened to be correct sometimes and wrong in others. In some other cases, the phrasal verbs were not complete; i.e., the adverbial is absent.

- play a significant role ~~***on***~~ ***in*** the efficiency …
- The present oils were ***constituted of*** high levels of bicyclic monoterpenes.
- … that researchers ***rely*** heavily ***on*** the statistics of previous experiments.
- The results are associated ~~***to***~~ ***with*** …

5.2.2. Lexical Errors

Lexical errors (32.45%) refer to problems in word usage; whether it is wrongly chosen words or incorrectly ordered. The detected lexical errors showed the gap between these students' lexical knowledge and their communicative needs. Nine types are distinguished and categorised in the table below:

Table 45. Categories of Lexical Errors

Category	Sub-category	Frequency
Lexical	Word choice	477 (23.26%)
	Spelling	337 (16.43%)
	Article	312 (15.21%)
	Incorrect plural	308 (15.02%)
	Word order	224 (10.92%)
	Semi-technical terms	208 (10.14%)
	Part of speech	102 (04.97%)
	Addition or Omission	83 (04.05%)
	Total	2051 (100%)

5.2.2.1. Word Choice

Word choice errors shape 23.26% of lexical errors. They refer to the use of a word where another one is needed, not necessarily different in type; for instance, a noun instead of another noun. The main reasons for such errors were: word-for-word translation;

unfamiliarity with collocation, word preference, and word in context; and French interference.

Word choice is important in writing because it helps communicate ideas and findings clearly and concisely. Appropriate word choice helps to maintain clarity and an academic tone.

Examples:

- The ~~***reach***~~ ***rich*** clay …
- the ~~***likelihood***~~ ***probability*** of reactions …
- The compounds ~~***assayed***~~ ***tested*** by GC were identified …
- has been ~~***severely affected***~~ ***stopped*** by the addition of alcohol.
- a metal coating ~~***who***~~ ***which*** is called thermal barrier.
- In contrast, variations in the compositions of essential oils isolated from fresh flowers and dry flowers on the one hand, and from fresh stems and dry stems on the other hand, ~~***merit***~~ ***require*** some explications.

Another common error that frequently appeared in the students' papers was **contraction** which is not supported in academic formal writings (it's - that's - doesn't - don't - didn't).

5.2.2.2. Spelling Errors

Spelling affects meaning and comprehension; therefore, it is significant in communication. Concerning spelling, it is important to note the difference between errors and mistakes. A spelling error is when a learner consistently makes the same misspelling all over their piece of writing. However, a spelling mistake is when a learner occasionally misspells a word which most of the time s/he spells correctly (Ellis, 1997, p. 17). Therefore, the errors spotted and mentioned in the examples were repeated more than once in the students' papers.

Spelling errors detected in the students' papers showed several resources: wrong compounds, plural uncountable nouns, French spelling especially technical terms and simply incorrect spelling. Some of these spelling errors really affect the meaning (adsorb vs absorb).

Examples:

- Compound words:

superalloys → super alloys

Xray → X-ray

hydrochemical behaviour → hydro chemical behaviour

temperaturemean → temperature mean

- Uncountable Nouns:

Equipements → equipment

Evidences → evidence

Informations → information

- French Spelling:

Flavonoides → Flavonoids

Benzoique → benzoic

Metallique → metallic

Equilibered → equilibrated

Acide → acid

Polluant(s) → pollutant(s)

Organique → organic

Marqued with a great development → marked with a great development

- Incorrect Spelling:

Chows → shows

Coleur → colour

properteis → properties

5.2.2.3. Articles

There are two frequent errors with articles in the students' papers. The first error concerned the definite article *the* whether addition or omission of the article (which is a common problem among most NNS writers of English in general). It is difficult for them to determine whether to use an article or not. The second, which concerned the indefinite article, was of three types: the use of the indefinite article (a/an) with plural words or uncountable nouns, the use of **an** with words that start with a consonant sound and omission or addition of the article.

Examples:

- The Definite Article Errors:

can help ***~~the~~*** **Ø** engine designers to define ***~~the~~*** **Ø** more promising strategies

exceed the standards of the water intended for consumption and ***~~the~~*** **Ø** irrigation.

~~Ø~~ ***the*** gas phase

~~Ø~~ ***the*** Jmol program

~~Ø~~ ***the*** DFT method

- The Indefinite Article Errors:

~~A~~ **Ø** tension stresses

as ***~~a~~*** **Ø** Laves phases

~~A~~ **Ø** fresh water

integrating ***~~a~~*** **Ø** mechanical, chemical and physical knowledge.

~~An~~ **a** herbal drug …

~~A~~ ***an*** herbicide

a composite material can be ***~~a~~*** **Ø** challenging, …

cannot be interpreted with only ~~***a***~~ single bubble results from…

5.2.2.4. Incorrect Plural

In scientific writing, the use of long noun phrases with many nouns (in addition to adjectives and other particles) is often. It was noticed in the students' writing that they pluralised all the words in a plural noun phrase ignoring the fact that some of these words are adjectives. The rule in such case says to find the principal noun in the phrase (the head noun) and to pluralise it. The rest of the words -mostly- act as modifiers (adjectives particularly).

Examples:

- The high-pressure**s** turbine**s** blades coatings make possible to improve the engine efficiency. → The high-pressure turbine blades' coatings make … (main noun "*blades*"; "*coatings of …*" possession).
- certain samples can suggest chlorides and sulfate**s** salts dissolution → … sulfate salts ("*salts*" main noun)
- of flavonoid**s** series and its derivatives → … flavonoid series ("*series*" main noun)
- The compounds structures → the compound structures / the structures of compounds (possessive)

5.2.2.5. Wrong Word Order

Word order error is putting words in the wrong order. The wrong placement of words in the sentence affects the sentence structure and may lead to confusion and wrong interpretation of meanings. Most of the detected cases were the placement of the adjective after the noun it modifies.

Examples:

- during the seasons dry → during the dry seasons
- in a way continuous → in a continuous way
- both doses tested were analysed → both tested doses were analysed

5.2.2.6. Semi-technical Terms

One of the lexical problems detected in the students' writing was related to semi-technical words. The problem was not at the level of the meaning and use of these words but with their unfamiliarity with them. In other words, students' ignorance of the existence of such words and their technical use in scientific contexts lead them to provide an extra -unnecessary- explanation for each of these words whenever they mention them all over their papers. To remember, semi-technical words refer to the terms that are ordinary in nature (i.e., have at least one general meaning) and technical in use (i.e., have a different meaning when used in a specific context). Usually these words are already known in their contexts and do not require clarification.

Examples:

- The samples of the sand used in the experiment was taken from the banks (~~***edge***~~) of the river.
- … by dissolving anhydrous ferric chloride in hydrochloric acid of the required formality (~~***concentration of the solution***~~).
- The produced energy to current conversion efficiencies (~~***current here means the flow of charge carriers***~~) …
- While a number of mechanisms could explain the observed reactivity patterns, it is hypothesised that migration (~~***the movement of atoms***~~) occurs from a common catalytic intermediate …

(In addition to other words such as: *well*, *gate*, *organic*, etc.)

5.2.2.7. Part of Speech

Part of speech errors refer to the errors that concern the use of a word category where another is needed such as a noun instead of a verb, an adjective in place of an adverb, comparative form instead of superlative form of an adjective, (or vice versa) etc.

Examples:

- ~~***The air elimination***~~ ***the air was eliminated*** from the solutions ~~***was performed***~~ by bubbling Argon gas.
- ~~***The evaluation of results was done***~~ Results ***were evaluated*** using SpectraPlus software v. 1.70 (Socabim).
- the bubble population was found to be ~~***frequency***~~ ***frequent*** and power-dependent.
- the problem of interaction between mechanical and ~~***environment***~~ ***environmental*** parts in the turbine.
- Currently, the stresses in the external interface are ~~***strongly***~~ ***stronger*** than the inside interface …

A similar error was found to be related to the choice of the right pronoun. In several cases, the students erroneously used personal pronoun subjects instead of personal pronoun objects or vice versa.

Examples:

- ~~***Them***~~ ***they*** can make the chemical bond.
- The MFD methods were tested on ***them*** ~~***they***~~ and the results …
- The Mediterranean region is well known for ~~***her***~~ ***its*** seasonal climate.

5.2.2.8. Addition or Omission of Words

Most of the previously mentioned errors comprised the problem of addition and omission of words. This category of errors includes other cases of omission or addition where the students omitted (erroneously) an important word from the sentence that certainly affects the meaning or added an extra word that was not necessary in the sentence. The omission of necessary words involved omitting the main noun in a noun phrase, the auxiliary in a compound verb, the conjunction that shows the relation between words in a list (and, or, …), etc. For instance:

- The follow-up of several physicochemical parameters provided the image of a relatively intense ***pollution***.
- A semi-arid region ***is*** subject to ground waters salinity.
- marked an increase in total carbon in the burned ***plots***.

The addition of unnecessary words is considered redundancy that adds nothing to the meaning of the sentence. For example:

- When the pH value reaches ~~***a value of***~~ 6.
- the solar ~~***light***~~ radiation
- and with other present species ~~***exist***~~ in the compound,

5.2.3. Stylistic Errors

Stylistic errors refer to problems related to the *style* of scientific writing which is determined by the characteristics of science and the scientific discourse (mentioned earlier in this work). Clarity, preciseness, validity, logic and audience are some of these characteristics. A sentence can be correct at the grammatical and lexical levels but when it comes to style, it contains a problem which might affect meaning like the sentence below:

- a volume of 5L was taken in ***quite*** clean plastic containers.

This sentence is grammatically correct but inappropriate in scientific context because it is not accurate. The word "*quite*" indicates a certain degree of cleanness of the plastic containers which is not precise or exact.

Most of these errors are due to lack of care and awareness in addition to the writers' desire to beautify and decorate their writings, which is an unsupported thought in science communication. The readers are expected to draw conclusions that are based on the strength of the data being presented, not on the beauty of the language. Table 46 below shows a classification of similar errors into types of stylistic errors.

Table 46. Classification of Stylistic Errors

Category	Sub-category	Frequency
Style	Personal language	514 60.90%
	Value judgement	172 20.38%
	Redundancy	58 06.87%
	Ambiguity	57 06.75%
	Coherence	43 05.10%
	Total	844 100%

5.2.3.1. Personal Language

The most frequent of the stylistic errors in the students' papers was personal language with a dominant percentage of 60.90%. The use of personal language means the employment of the speakers' pronouns (I, we, me, us, my, our, etc.) in addition to other expressions and styles which indicate the appearance of the scientist in her/his paper as a major participant in the work. This language emphasises the performer of the work and not the work itself or its results which is not encouraged in science communication simply because the scientific work is expected to be repeated; i.e., anyone -following the same procedures- is able to repeat an experiment and obtain the same results.

For example:

- *We conclude that ..., I can say that ... I have noted that ... We added 10cL of water ... I expect the bond to break ... The results obtained by us are ... In our experiment, my observation, my notes, our laboratory conditions, the samples we have selected, etc.*

It is not only about the use of personal pronouns that refer to the researcher, but also employing some verbs and sentence structures with active voice giving emphasis to the writer. For instance:

- *We agree with the literature* the present oils were constituted of bicyclic monoterpenes.
- *Our studies* concern one of several systems that *we call* thermal barrier coatings.

5.2.3.2. Value Judgement

It refers to a subjective judgement of the worth, quality and rightness of something. Subjective remarks shaped by personal opinions and feelings are far from the scientific style and therefore should be avoided. Such errors give an unclear and inaccurate meaning to the communicated ideas. Therefore, expressions that contain value judgement are better omitted or replaced with more precise ones.

Examples:

- the compound should have an appreciable ductility (*high*)
- the Laves' phases have a good hardness / a good adherence (*high*)
- a given application requires insuring a good durability in its conditions of employment (*sufficient*)
- it becomes a hot* topic of research (*an interesting*)
- The result was found to have excellent* agreement with experimental and numerical results. (*better omitted)

5.2.3.3. Redundancy

Redundancy is the use of more words than necessary which is against the economy of language as a feature of scientific writing. It usually refers to expressing the same idea more than once or duplicating ideas unnecessarily. This kind of repetition affects the style of the paper. Redundant expressions are usually unintentional but their frequent appearance affects readability and conciseness and causes the writing to be boring and ambiguous in some cases. For some students, redundancy or repetition means to be informative and explain what was mentioned in order to make it clear and understandable.

Examples:

- After the calculation of the parameters, we represent them in a diagram. → The parameters were calculated and represented in a diagram.
- the method allows to test a variety of different molecules → … a variety of molecules / … different molecules.
- <u>to focus the emphasis</u> on the structure of the solution → to emphasise the structure of the solution / to focus on the structure of the solution.
- Fires are popular especially in summer ~~***season***~~.
- Sampling began immediately <u>after the fire</u> according to the following time intervals: 15 days, 1 month, 3 months, 6 months, 9 months, 12 months, 18 months and 24 months ~~***after the fire***~~.

5.2.3.4. Ambiguity

Ambiguity is the opposite of exactness. It is the possibility of a statement to be interpreted in more than one way. Obviously, the scientific discourse does not allow such possibility because communicating science should be accurate and precise.

Examples:

- the water samples are better taken in beakers or flasks and test tubes.

→ There are at least two meanings for this utterance: the choice is between: *beakers* and *test tubes* AND *flasks* and *test tubes* OR between *beakers* (alone) AND *flasks* and *test tubes*. [the addition of "either" can solve the problem here].

- The bacterial pathogens including food spoilage bacteria Pseudomonas aeruginosa ATCC 27853, and food-borne pathogens namely, Enterobacter aerogenes, Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 43300, the reference strains were obtained from the Pasteur Institute (Algiers) while Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Klebsiella pneumoniae, and

Morganella morganii <u>which</u> were clinical isolated from the laboratory of bacteriology, Benbadis Hospital, Constantine, using conventional methods (clinical isolation) [31].

→ ambiguous; no clear cut:

- the subject of the verb "*were obtained*" is not clear. Three possible subjects: "The bacterial pathogens" OR "Enterobacter aerogenes, Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 43300" OR "the reference strains".

- *which* is additional.

- *clinical* is supposed to be an adverb: **clinically**.

5.2.3.5. Coherence

Coherence is defined as "the logical bridge between words, sentences and paragraphs" (Coherence in Writing: Definition & Examples, 2017). A text which lacks coherence is hard to follow and its ideas are not logically organised. Coherence missed in the analysed papers was mainly about:

➢ parallel words in a list:

▪ the bulbs were used to *measure* the fluids, *transporting* them and *mixing* them. → …to measure …, transport and mix.

➢ unclear reference to previously mentioned words (especially pronouns):

▪ In order to investigate *its* effect on photocatalytic degradation of MBTU, different concentrations of oxalic acid were added into the reaction system, *respectively*.

- (Both *its* and *respectively* have no clear reference) → In order to investigate oxalic acid effect on photocatalytic degradation of MBTU, different concentrations were added into the reaction system.

➢ the use of different words (thought to be synonymous) with the intention of avoiding repetition:

- divergent instead of different / monitoring for observing / diminution for decrease

5.2.4. Explanation of Errors

After the classification of errors according to their types, it is important to recognise their origins. Identifying the sources of errors helps to find and design the appropriate solution and remedy for them. The search in the origins of errors may reveal their pattern; and so, know how to avoid them. In other words, explaining the sources and causes of errors to the students in question raises their awareness about them and make them more careful in future writings. The detected errors in this study can be classified into the three main sources mentioned earlier: interlingual, intralingual and unique. Table 47 below presents a statistical classification of errors according to their origins.

Table 47. Statistics of the Sources of Errors

Sources of Errors	Frequency
Interference	3084 (48.79%)
Developmental	2705 (42.79%)
Unique	532 (08.42%)
Total	6321 (100%)

5.2.4.1. Interference of another Language

Interlingual sources of errors refer to interference of another language. Errors which occurred because of the interference of another language are the most occurred of the identified errors with a percentage of 48.79%. Interference or transfer errors typically refer to the use of the learners’ first language (Arabic for these students) on some features of the target language (English). However, the interference found in these students’ papers was of French not of Arabic. French, as mentioned earlier, is the second language for the students and the language of their studies. Additionally, those students seemed to master the French language as if it was their mother tongue and they use it in communicating not only science but for several other purposes.

Examples of these errors are most technical (chemical) words (such as: *particule* for particle; *catalyse* for catalyst; *organique* for organic) because usually such terms come from the same origins in the European languages. Other common transfer errors are related to sentence structure and word order such as: *chemistry organic* for organic chemistry and *reaction chemical* for chemical reaction.

5.2.4.2. Developmental Errors

A study in the errors extracted in this investigation reveals that both intralingual and developmental sources can be seen to be similar or cause one the other. In other words, intralingual errors, which refer to misunderstanding or lack of learning of the language rules, how to apply them and in which conditions, led to committing developmental errors which refer to generating hypotheses from previously built -incomplete- knowledge about certain points. Both sources were seen in most of the grammatical errors mentioned above because they have learnt little about grammar rules and used this little and applied it wherever they thought it was suitable.

Generalisation or overgeneralisation, as the dominant source of most errors, refers to when the students usually apply the regular rules of grammar to irregular items (verbs and nouns that do not follow the rules or are considered exceptions); for instance, adding ***-ed*** to all verbs in past tense and ***-s*** to all plural nouns, using ***to*** with almost all modal verbs, etc. Another example is the *over* use of the passive voice in most of their writings which is due to their false thought about scientific writing.

5.2.4.3. Unique Errors

Unique errors are those which are neither interlingual nor intralingual. They are also seen to be caused by luck of knowledge and training in certain language points. These errors are the result of the techniques created by the students to fill in the gaps of learning they had. These errors can be exemplified with the use of link words and cohesive markers which students learnt or deduced their use from the texts they have read (usually erroneously). In addition, the personal language and value judgement were the result of their generated ways of starting new sentences and describing things (respectively) which they thought were appropriate and correct.

5.3. The Second Analysis: Results and Discussion

A new group of articles were analysed in searching for errors. These articles were written by the same students after attending the English for science course provided by the researcher as part of this investigation. The aim of this analysis was to check to what extent the course benefited the students and helped them improve their writing. It also aimed to see if there were other errors (which may indicate other problems or weaknesses) and also know if they correctly grasped what they have learnt and could really improve their level in writing in English.

The second analysis showed that the students became more aware of certain points in writing in English and learnt to pay attention to the language while constructing their articles. In other words, they have learnt to write taking into consideration the language as much as they care for the content of their papers.

After the lessons, the students started writing and shared the following comments:

- The writing process seemed different but easier than it was before.
- They became able to choose the right word or look for the appropriate expressions to use.
- They became aware of selecting the correct tense.
- They learnt how to avoid personal language and use both active and passive voice appropriately.

- They were able to differentiate between French and English spelling and check for the sentence structure and order of words.

- Some of them planned their writing according to the lessons: the sections, the tenses, commonly used expressions, the titles, the tables and figures, etc.

- They have generated new strategies in writing including: Check for mistakes, ask when in doubt, balance the use of technical terms, etc.

- They have also learnt how to understand and respond to reviewers since they used to find difficulties understanding their comments.

The errors detected in the second analysis were in language points that were not tackled or discussed in the lessons. These points are as important as the previous ones but the time and possibility to meet did not allow for more than the presented lessons. The most frequent of these errors are represented in table 48 below:

Table 48. Types of Errors Detected in Analysis Two

Types of Errors	**Frequency**
Punctuation	476 (43.59%)
Verb Form	235 (21.52%)
Saxon Genitive	183 (16.76%)
Sentence Structure	107 (09.80%)
Unsuitable Words	91 (08.33%)
Total	1092 (100%)

It is noted that most of these errors are grammatical except the last type which can be either considered lexical errors (choice of words) or stylistic errors (some of these words describe a value judgement). This is due to the fact that the English grammar contains a large number of details including different rules, structures, exceptions, etc. That is why it was not possible (feasible in this investigation) to provide all the grammar lessons for the students for this would have taken more time and efforts.

5.3.1. Punctuation

It is clear that the students got rid of the comma after the subject (or between the subject and main verb) -as this was the most frequent error in punctuation in the first analysis. However, other punctuation marks were wrongly used because of lack of knowledge about them. The examples extracted from their new papers showed that their problem with punctuation was in long, compound sentences which comprised parts in brackets. For instance, they put the full stop between items of a list instead of a comma especially when those items were long or contained abbreviations, numbers, symbols, etc. These misplaced full stops created sentence fragments.

Example:

- X *The C(4)-C(5) and C(4)-C(9) bonds in the HOMO are binding, but the C(4)-C(9) bond in the LUMO is anti-binding (Figure 4). Due to electronic transfer through LUMO back-donation or HOMO electronic donation, the bonds C(4)-C(5) and C(4)-C(9) lengthen.*
  - X *The C(4)-C(5) and C(4)-C(9) bonds in the HOMO are binding, but the C(4)-C(9) bond in the LUMO is anti-binding (Figure 4) due to electronic transfer through LUMO back-donation or HOMO electronic donation, the bonds C(4)-C(5) and C(4)-C(9) lengthen.*

5.3.2. Verb forms

The only detected errors concerning verbs and tenses were those of irregular verbs in past simple and past participle forms. The students showed that they became aware of the choice of the right tense but they lacked knowledge of irregular verbs in past forms. They were taught of the existence of these verbs but they did not learn or memorise them all.

Examples:

- *begined* for began;
- *falled* for fell/fallen;
- *growed* for grew;
- *holded* for held; etc.

5.3.3. The Saxon Genitive

The excessive use of the possessive ***'s*** created ambiguous and unclear sentences. Normally, they are not used with objects; ***of*** is preferred in such cases.

Example:

X *Multitask Quantum Study of the Curcumin-based Complexes*' *the Physicochemical and Biological Properties.*

✓ *Multitask Quantum Study of the Physicochemical and Biological Properties of the Curcumin-based Complexes.*

X *the separation of the deformation density*' *contributions originating from different components*

✓ *the separation of the contributions of the deformation density originating from different components*

5.3.4. Sentence Structure

Some of the errors related to sentence structure detected in the second analysis were also found in the first analysis and dealt with in one of the lessons. These errors showed that the students' main problem was with long sentences containing long, complicated noun phrases as subjects or compliments. The use of symbols and explanation of abbreviations in addition to the lack of knowledge of punctuation are the direct reasons behind such errors. The best solution to them is to write and revise carefully paying attention to every detail; i.e., highlight the main subject and use a conjugated verb.

Examples:

- X *Four approaches* ***which*** *are widely used to describe chemical bonds[9]: The quantum theory of atoms in molecules QTAM[10-13], the interacting quantum atoms (IQA) energy decomposition scheme[14-16], the noncovalent interactions (NCI) method[17-19] and the extended transition state (ETS)[20] with natural orbitals for chemical valence (NOCV) energy decomposition scheme.* (sentence fragment)
  - ✓ *Four approaches are widely used to describe chemical bonds[9]: The quantum theory of atoms in molecules QTAM[10-13], the interacting quantum atoms (IQA) energy decomposition scheme[14-16], the noncovalent interactions (NCI) method[17-19] and the extended transition state (ETS)[20] with natural orbitals for chemical valence (NOCV) energy decomposition scheme.*
- X *The main optimized geometry parameters, metal-metal and metal–CO bond distances, associated with the data from X-ray crystal diffraction available.* (no verb)
  - ✓ *The main optimized geometry parameters, metal-metal and metal–CO bond distances, associated with the data from X-ray crystal diffraction available* ***were measured****.*

5.3.5. Unsuitable Words

Some words are seen to be inappropriate in the scientific context because they either represent unmeasurable entities or description, or have unclear meaning. Both are against the characteristics of the scientific discourse. These words can simply be omitted and should be avoided in future writing.

Examples:

- *obviously*; *clearly*; *the best result*; *perhaps*; etc.

5.4. Interpretation of the Results

5.4.1. Putting it All Together

The experiment which was carried out in this research aimed to find, suggest and test a solution for an observed problem that concern English users. The problem was the insufficient learning and incorrect use of the English language by a group of Algerian science students who proceed their PhD studies and need to write and publish scientific articles in English. The recommended solution was to provide these students with the required lessons around the language points they usually find difficulties with. The experiment was done over three main phases: detecting the students' errors to find the areas of difficulties (by analysing their articles), presenting these areas in form of lessons to fulfil their learning gaps and enhance their performance (writing), and checking the efficiency of these lessons by analysing new articles written after the lessons. This experiment aimed to find a convenient way to teach the English language for science students and for similar users of the language who share the same needs.

5.4.2. Implications of the Study

The final finding of study (students' writings after the lessons) delivers the predicted visions which said that if science students became aware of their needs, weaknesses and difficulties with writing scientific articles in English, they would improve their scientific language and develop their writing skill, particularly writing scientific articles. The hypothesis of the research which appears to be a simple, obvious one (if students are trained well, they will improve their performance) is in fact deeper than that. The hypothesis carried the purpose of anticipating and checking the reasons behind science students' difficulties with English. Thus, the study aimed to test the training that science students had -if any- by digging into the knowledge gaps mainly in their previously studied English. It tested whether these gaps were in their low level, lack of interest and motivation, insufficient former learning, or in something else (to be found). Accordingly, it can be said that the hypothesis sought to find the weaknesses, understand the needs, and build the right remedy on the basis of these needs and weaknesses. It also showed the importance of defining the students' needs in designing the English curriculum and provide what is required in addition to the significance of ESP/EST instead of general English.

In the light of the hypothesis, the investigation and the findings, this research is seen to be useful to improve and develop learning and teaching English for science students. English is proved to be an important tool that every scientist and science student must acquire for the importance it gains in their studies and research career. Therefore, English for science should be part of their -most necessarily- university studies and this part should be delivered appropriately. One way to achieve this goal is to relate and build the English curriculum according to their needs and requirements.

The first major practical contribution of the study is that it highlights much needed information about both science students' needs and difficulties in addition to the -possible- gaps of learning and teaching English to such students. These details can be useful for course designers and teachers of English to decide upon the content of the English curriculum for science students in the Algerian universities.

Another implication is suggesting a promising and suitable remedy to close these gaps (with the possibility to be enhanced). It shows (in their reaction to the training course and performance in further writing) the importance of knowing and understanding the needs and objectives to learn English.

5.4.3. Limitations of the Study

The real aim of this investigation was to find the difficulties that Algerian science students usually encounter with when writing in English and also to suggest and test a possible way to overcome these problems. The results of this study showed that the problem is deeper and wider than expected; however, the suggested solution was not enough to overcome this problem because of the methodological limitations. Thus, the findings of this study should be seen in light of some limitations:

- The findings cannot be generalised for it is not known how English is taught in all science departments in the Algerian universities;
- The students' point of view or opinion of the English lessons -they had at university or even before- is to be considered subjective for they might have forgotten or they could have shown less interest in English back then unaware of its importance.
- Their unawareness of the importance of English until late stages of their studies and career.
- There might be other needs and weaknesses that this study could not reveal.
- The level of this kind of students in English is not necessarily similar to the sample population selected in this study.
- It was not possible to find a larger sample population even if the target population itself is considerably large. The problem was the nature of the population (PhD science students who shared the same difficulties in English) who are usually busy working, travelling, or being from different cities making it difficult to meet and gather for conducting an investigation as such which included a tutoring course that required the presence in certain time and place.
- The teachers who taught these students could have not been familiar with or trained in the required content (EST).
- Not every important lesson was provided in the tutoring phase; it was not possible to present all required lessons.

- The provided solution (lessons) could be improved and enlarged in number and content and even ways of presenting them. It can be said that this study tested the suggested remedy for it can be improved in the future.

Therefore, providing a way that enables to contact the entire population and investigate in their difficulties which are related to communicating in English can be a good solution to improve these limitations in the future. With the progress in distant-communication technology, finding such a way is possible and the investigation becomes feasible. In addition, the statistics can be more reliable to create a guide for science communication in English and make it useful and available for the entire population.

Conclusion

In this chapter, the results of the investigation conducted in this study which were obtained by means of the questionnaire and the two -error- analyses of scientific articles were stated. These results were discussed and interpreted in order to come up with the gist of the research in an attempt to find solution to the identified problem. This chapter also included answers to the research hypothesis and questions, the implications of the study in the light of its limitations and how they could be improved in future research for better results and effectiveness.

Science students have certain needs in English but several reasons caused them to face difficulties. The investigation searched and stated these reasons, and also suggested and tested solutions to overcome them. This confirmed the hypothesis which said that the students' awareness of their weaknesses and their necessities help them know what to do, what to learn, how to write, what to correct and how to revise. In other words, science students would learn how to write scientific articles if they were provided with the necessary details about the articles and the language (English). The English language teaching and learning should take learners' needs into considerations.

General Conclusion and Recommendations

English was a new requisite for PhD science students when they had to read documents, analyse texts to extract information and write scientific articles. These students' knowledge of the language was not sufficient to fulfil such tasks.

This new acquaintance with English led to the emergence of several difficulties as it uncovered the gaps and weaknesses not only in the level of the students but in the way English is/was taught at university or in previous stages. EST was not appropriately delivered or was not introduced at all.

The main problems and difficulties revealed by this investigation were mainly around the students' level, their needs and their awareness of their needs. These problems can be summarised as follows:

-The low level of -most- students which was due to lack of care about the language mainly because of their ignorance of its importance and role in their career.

-The impact of French (in particular) thinking that science and scientific terms are similarly expressed in both languages.

-They only had English as an extra module in which they had terminology in the finest cases. In other words, they did not have a convenient training in EST that could prevent most (if not all) of these problems and weaknesses. The content and the importance given to the English language did not meet the required minimum standards and did not show the role of English in the life of scientists.

-The (arbitrary) strategies generated by the students (which were not always convenient or practical) in an attempt to overcome their difficulties with the language specifically with writing in English.

-Their fear and hesitation to write scientific articles in English for three main reasons: lack of knowledge of English, the importance and position of the scientific papers in their studies and the publication obligation. This fear can be the result of some of their previous failed attempts to publish which were mostly due to poor and insufficient language proficiency.

For this, it was hypothesized that if they became aware of their difficulties and needs, they would improve their performance in such tasks especially with writing scientific articles. To check the hypothesis, two main tools have been used; a questionnaire given to the sample students to have a generic view on their problems; and an error analysis of their articles to detect their exact difficulties mainly with the language. The sample students received a training (lessons) that was based on the detected problems. In order to check the success of the training, new articles written after the training were analysed.

Of five chapters, this study tries to see into the crux of the students' problem. Chapter One is a presentation of scientific writing and its characteristics. Chapter Two discusses the scientific article, its format and features. Chapter Three provides details about the frequent language features in the scientific article. Chapter Four presents a description of the investigation and treatment which were carried out in this study. Chapter Five presents, discusses and interprets the results.

The results of the applied investigation have allowed the researcher to say that the hypothesis is to some extent confirmed. In the light of this, the researcher advances the following recommendations.

- Improve the way of dealing with English in universities and even in previous stages.

- Design English course/curriculum according to students' needs.

- Make such courses more practical and richer enough to achieve the required purpose.

- Investigate widely and deeply in the other needs and required skills of the students that are related to the language such as reading, speaking, conducting meetings and conversations, etc.

- Design a guide for science students to help them write scientific articles in English.

- Create a cross-disciplinary system that enables coaching and preparing teachers of EST that are familiar with the scientific branch/field of the leaners such as chemistry, physics, biology, etc.

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Appendix 1

Teachers Pilot Questionnaire

Dear colleagues,

This questionnaire is a part of a research study. It is addressed to you as teachers of English in science (chemistry/physics/engineering) departments. It aims at knowing some details about teaching English for science students mainly concerning content, methods and suitability.

You are kindly requested to answer the following questionnaire. The answers will be anonymously analysed. Feel free to explain or to comment on any question.

Your assistance is highly appreciated.

Ms. Kaouther BOUDJEMAA

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University of Constantine 1

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1. What did you study at university?

……………………………………………………………………………………………

2. Are you a vacant or certified teacher?

☐ vacant ☐ certified

3. How many years have you been teaching in the chemistry/physics/engineering department?

……………………………………………………………………………………………

4. Do you teach only in this department?

☐ Yes ☐ No

5. What level(s) do you teach?

……………………………………………………………………………………………

6. How many sessions/hours per week is devoted to English for each class?

……………………………………………………………………………………………

7. What do you teach exactly?

……………………………………………………………………………………………

8. Who decides the content of the programme?

……………………………………………………………………………………………

9. What sources/materials do you rely on to prepare the lessons?

……………………………………………………………………………………………

10. Are the topics you teach up-to-date?

☐ Yes ☐ No

11. Are the students you teach interested in the content you provide?

☐ Yes ☐ Sometimes ☐ No

- Please, explain why.

……………………………………………………………………………………………………

12. Do students attend your sessions regularly?

☐ Yes ☐ No

13. Do you face difficulties with students' level?

☐ Yes ☐ No

14. At what points exactly do you find difficulties?

……………………………………………………………………………………………………

15. What can be more useful or interesting for these students?

……………………………………………………………………………………………………

Thank you for your participation. ☺

Appendix 2

The Students Pilot Questionnaire

Dear students,

You are requested to participate in the current research through filling in the questionnaire below. Please, tick the appropriate box (√) or answer with full statements when necessary.

Thank you very much for your cooperation.

1. In what language did you have your studies at university?
☐ Arabic ☐ French ☐ English ☐ Other (specify) …………
2. Did you study English at university?
☐ Yes ☐ No
-If yes:
- How many sessions per week? ………………………………………
- Do you think it is enough?
☐ Yes ☐ No
- To what extent the English courses helped you enhance your level in English?
☐ completely ☐ partially ☐ slightly ☐ not at all
- What lessons did you have in these English courses?
☐ Grammar ☐ Vocabulary ☐ Writing
☐ Reading (texts) ☐ Others (specify)
3. What do you think your level in English is?
☐ High ☐ Average ☐ Low
- How would you justify you level?
4. Do you think your current level in English allows you to write / read English documents (articles)?
☐ Yes ☐ No
5. As a PhD student:
- In which language do you write your thesis?
☐ Arabic ☐ French ☐ English ☐ Other (specify) …………
- In what language do you have to write your article(s)?
☐ Arabic ☐ French ☐ English ☐ Other (specify) …………
- Why?
- Have you written -journal- articles up to now?
☐ Yes ☐ No
- If yes:
- In what format? ……………………………………
- What difficulties did you encounter with when writing your article(s)?

6. In what language do you usually find the documents you need in your studies?

☐ Arabic ☐ French ☐ English ☐ Other (specify) …………

- Can you explain why the documents you need in your studies are found in this particular language(s)?

7. Would you like to learn?

☐ English for Science and Technology ☐ General English

- Justify your choice, please: ………………………………………

8. Based on your experience, the English courses for -university- science students should cover:

☐ Vocabulary / Terminology
☐ Grammar Rules
☐ Written Expression
☐ Reading Comprehension
☐ Others. Please, specify.

9. According to your needs, order the following skills from most necessary (1) to least necessary (4)

☐ speaking ☐ writing ☐ reading ☐ listening

- Can you please explain your order?

10. If you do not understand what you read when you are reading a document in English, what do you do?

☐ Translate
☐ Use dictionary
☐ Use the Internet
☐ Ask for help (from teachers or others)
☐ Other methods. Please specify:

11. How do you overcome your deficiency in writing in English?

☐ Write in your mother language then translate into English
☐ Use dictionary/Internet
☐ Ask for help
☐ Imitate/copy other papers' style
☐ Other methods. Please specify:

12. Do you think the techniques you have selected or mentioned in the previous questions (10 and 11) are efficient?

☐ Yes ☐ Sometimes ☐ No

- Justify: ……………………………………

13. As science students: what do you suggest to improve the English courses at university and make them meet your needs?

Thank you for your participation. ☺

Appendix 3

Students' Main Questionnaire

This questionnaire is being conducted as part of a doctoral research work. It is addressed to -postgraduate- science students in Algeria. It aims at identifying the weaknesses and difficulties they confront with when writing scientific articles mainly concerning the English language. It also seeks to investigate these students' ability to improve their level in writing scientific English and overcome their difficulties.

The results of this questionnaire will help us get better understanding of the main sources of this problem and allow us to design and implement more effective courses for science students.

The information gained will be treated as strictly confidential and will be used for the purpose of this study only.

You are kindly requested to answer the following questionnaire. Please tick the appropriate box (√) or answer with full statements when necessary -in red colour. Please, feel free to ask any question concerning the questionnaire or the meaning of any of the questions.

Yours sincerely,

Ms. Kaouther BOUDJEMAA

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Part One: The Status of English in the Department of Chemistry

Q1. In which language did you have your studies at university (BA + MA)?

Arabic ☐ French ☐ English ☐

-Others, please specify. ………………………….

Q2. Did you study English -as a module- at university?

Yes ☐ No ☐

-If yes:

_When exactly? ………………

_How much time was devoted to English? ……………………

Q3. What did you study in the English courses?

☐ Grammar rules ☐ Translation

☐ Vocabulary (terminology) ☐ Writing

-Others, please specify. ……………………….

Q4. Have you dealt with scientific texts during these lessons (reading or writing)?
Yes ☐ No ☐

Q5. To what extent the English courses helped you learn the English you need?
☐ Very useful
☐ Somehow useful
☐ Not useful at all
-Please, justify your choice. ………………

Q6. At the beginning of your studies, did you know that you would need to use English at this stage (post-graduation)?
Yes ☐ No ☐
-Explain in both cases.

Part Two: The Students' Level, Interests and Difficulties in English

Q7. What do you think your level in English is?
☐ very good ☐ good ☐ average ☐ low ☐ very low

Q8. Do you need English in your studies as post-graduates?
Yes ☐ No ☐
-If yes, what for exactly?

Q9. Do you -usually- read in English?
Yes ☐ No ☐
-If yes, have do you read in English?
☐ books ☐ stories ☐ in your field only
-Others, please specify.
_Why do you read in English?
☐ To improve your level
☐ To get information about your studies
☐ To entertain
-Others, please specify.

Q10. When you read a text in your field of study (chemistry), do you fully understand it?
Yes ☐ No ☐

Q11. What points do you find difficult?

Q12. What do you do to understand the ideas of a text?
☐ Try to understand all the words
☐ Try to find the general idea of the sentence/passage
☐ Translate the text
☐ Use illustration (figures, schemas, …) to understand the text
-Others, please specify.

Q13. Did you have a training on how to read resources related to your studies in English?
Yes ☐ No ☐

Q14. What do you do to improve your level in English?

Q15. Do you write in English?
Yes ☐ No ☐

Q16. How often do you write in English?
☐ always ☐ often ☐ sometimes ☐ rarely ☐ never

Q17. When writing, do you have difficulties at the level of:
- ☐ Words
- ☐ Sentence structure
- ☐ Relationship between ideas
- ☐ Transition from one paragraph to another

-Others, please specify.

Q18. Do you think your level in English allows you to write -correctly-?

Yes ☐ No ☐

Q19. When you face a problem in writing in English, what do you do -usually-?

Q20. According to your needs, the English course should contain:

☐ grammar rules ☐ vocabulary (terminology)
☐ comprehension tools ☐ translation ☐ the writing skill

-Others, please specify.

Part Three: The Scientific Article

Q21. In your opinion, what is the importance of writing an article for science students?

Q22. Have you written Scientific Articles before?

Yes ☐ No ☐

-If yes, in which language(s)?

Q23. Have you got any training on how to write Scientific Articles in English?

Yes ☐ No ☐

Q24. Did you get / ask for help to write your article?

Yes ☐ No ☐

Q25. What format (layout) do you follow in your article?

Q26. Do you know the IMRaD format?

Yes ☐ No ☐

-If yes, how do you know it?

Q27. In what order do you write your Scientific Article (during the writing process)? (Use numbers 1-6)

☐ Abstract ☐ Introduction ☐ Methods and Materials
☐ Results ☐ Discussion ☐ Conclusion

-Justify your choice.

Q28. What difficulties do you face when writing Scientific Articles?

Q29. Do you think a scientific article can be rejected (by the journal you submit to) only because of language-related mistakes?

Yes ☐ No ☐

Q30. What do you suggest to make the English courses more effective and useful for science students in the future?

Thank you for your generous collaboration ☺

Appendix 4

Lesson Plan (1)

EST and the Scientific Discourse

Tutor: Ms. Kaouther BOUDJEMAA **Date:** Oct. 2016
Learners: PhD Chemistry Students **Duration:** 2/3 Hours

Aims:
- To introduce the field of EST and its importance in learning and using English for science.
- To make the learners aware of the nature of the scientific discourse.
- To highlight the reasons behind the dominance of the English language on science.

Materials:
-Handouts:
*The tree of ELT

Steps	Procedure	Objectives
Introduction (lead-in)	ESP= English for Specific Purposes - ESP is the use of English in a particular domain (work or study). - ESP is categorised into two major sub-fields which are: **EAP**= English for Academic Purposes **EOP**= English for Occupational Purposes This division is about the application of the language (why, where and when): *EAP*: for studies, research, publication … *EOP*: for work, instructions, professions … - Another subdivision of ESP on the basis of the specific purposes and the domains in which the language is used: **EST**: English for Science and Technology **EBE**: English for Business and Economy **ESS**: English for Social Sciences (Handout 1): (explain the figure) This is called "The Tree of ELT" *ELT= English Language Teaching English -in our case- is a foreign language; that is why we follow the EFL branch in the tree. So, there are General English (GE) and ESP **GE**: can be exemplified with: the English language courses we had in middle and high schools (including general grammar rules, word building, etc.) which was basically studied for exam purposes. **ESP**: is (supposed to be) taught for higher	➢ To introduce the lesson(s) ➢ To make learners aware of the existence of ESP and its sub-fields ➢ To introduce the field of EST ➢ To provide a better vision and position of EST

<table>
<tr>
<td>Presentation</td>
<td>education in universities; undergraduate, graduate and postgraduate students.

We can notice in the Tree of ELT that EST can be categorised into EAP and EOP:
For example:
You -as chemistry PhD students- need to learn English to use it in your studies: reading articles and books in your field of study, write articles about your findings, participate in conferences and -international- study days, etc. In this case, EST is seen to have academic purposes (EAP).
Later, when you graduate and become chemists, you will need English to work in laboratories, manuals, and industries (for instance). In this case, EST will have occupational purposes (EOP).

EST is defined as a branch in English teaching which is:
(1) designed to meet the specified demands of a learner, (2) related in content to particular disciplines, occupations and activities, (3) centred on the language appropriate to those activities in syntax, lexis, discourse, semantics, etc., and analysis of the discourse, (4) in contrast with general English. (Strevens, 1977, p. 2)

This definition summarises what the learners need to know about EST which is as follows:
(1) EST is mainly concerned with learners’ needs, i.e. what learners need to learn from the language and why they need to use it (read, understand, write …). You, as science students, are different from learners of the English language. The difference lies in the fact that you do not have to learn everything in and about the language (GE). It would be enough for you to learn what you need in order to improve your reading and writing skills as far as your main studies are concerned (EST).
(2) The content -in your case- is chemistry. Therefore, you need to learn the language used to express chemical ideas and activities. Always put in mind that you need the language to read and write.
(3) This specific use of the language appears in technical words, specific verbs (vocabulary, terminology) and sentence structure (grammar).
(4) All the previous factors made EST different from</td>
<td>➢ To explain and clarify the concept of EST with an operational definition, its components and main factors: important for science students

➢ To draw students’ attention towards the notion of specific lexis and syntactic features in</td>
</tr>
</table>

	GE in: • The objective of GE is learning the language; however, the objective of EST is to communicate scientific facts. • Unlike GE, EST takes into consideration the special needs of learners (what language features you need to use, how and why).	EST
***The Scientific Language**	The scientific English is different from other uses of the language because of the content it expresses = science. - What does science contain? ➔ Facts, experiments, discoveries … - How should this content be expressed? ➔ In a persuasive way; it is expected to be true through arguments, reasons, logic, etc. Therefore, the scientific language is persuasive (argumentative) in nature. In other words, communicating science is not only about stating and describing observations; it is about convincing audience that these are facts and realities. In addition to being persuasive, communicating scientific facts demands *clarity* and *objectivity*. -Clarity: if the idea (experiment, fact, etc.) is not expressed in a clear, exact way; it can be lost and misinterpreted by readers. -Objectivity: scientific activities (experiments, lab-work, researches …) need to be scientist-free. It means that the scientists who are carrying out these activities should not appear to be part of the activity (with few exceptions). As one of the characteristics of scientific experiments, they must be independent from the scientist (in most cases) in order for other scientists to be able to repeat them. That is to say, the results can be tested that if the experiments are carried out by another scientist, they must be the same. (verifiable) Objective means neutral also. In other words, the scientific work should be free from emotions, opinions and personal judgements.	➢ To explain the nature of scientific English and what makes it different from general English
***Why English?**	We can ask the following questions: - What makes English the dominant language on science and technology? - Why do you have to write in English and not in Arabic (mother tongue) or French (the	➢ To recognise why English is the language they have to learn and use (in order to raise

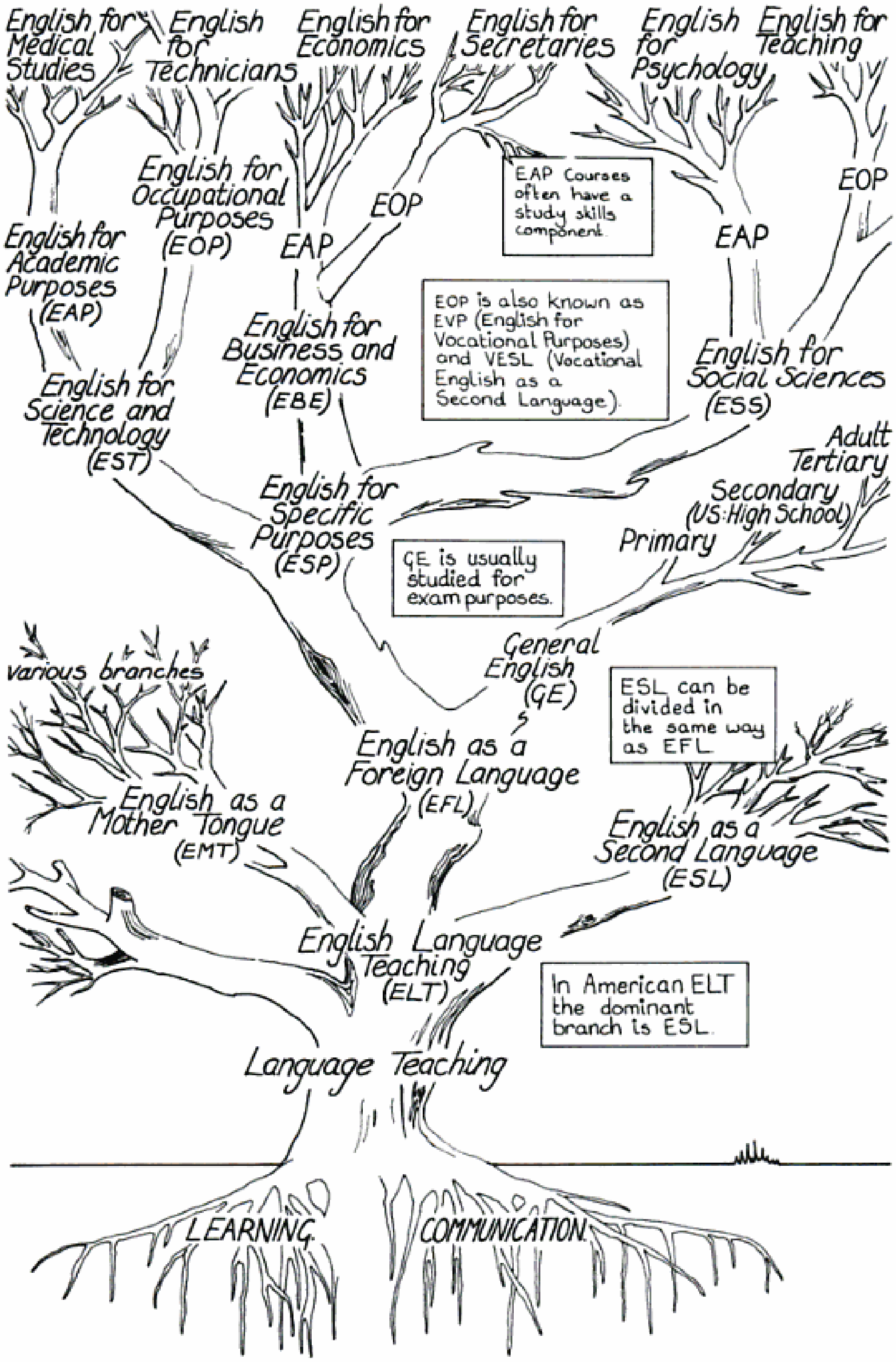
<table>
<tr><td></td><td>language of your studies)?

There are several reasons that make English the language of science, including:
_First, due to economic and political reasons: global wars, the industrial revolution, the American isolationism, USA and UK dominance on many fields including science, technology and business. (Unnecessary to go through)
_Second, the nature of the English language itself, English is flexible unlike other languages. Flexibility is one of the key features of the English language, which is reflected in its willingness to accept new words and phrases from different origins.
_Third, the huge number of publications in science, which are written in English.
According to (Huttner-Koros, 2015), “Newton’s Principia Mathematica was written in Latin; Einstein’s first influential papers were written in German; Marie Curie’s work was published in French. Yet today, most scientific research around the world is published in a single language, English”.
Statistics differ between 80% and 90% (or sometimes more) from one country to another depending on the journals or on the type of science being published (medicine, chemistry, physics, technology, biology, etc.).
That is why English is the language you have to use for publication.</td><td>their motivation and interaction with the lessons)</td></tr>
<tr><td>Feedback</td><td colspan="2">*Write:
-The students’ reactions and feedback about the lesson and the content being presented.
-The questions and enquiries asked by the students and the discussion occurred.
-The students’ level of motivation and interest about the content and its relevance to their needs.
-The tutor’s feedback about the success of the lesson: presentation, content, pace, degree of simplicity, materials, setting, etc. (what went well and what did not) to improve this and the next lessons.

→ These points are important to be taken into consideration in every lesson.</td></tr>
</table>

Appendix 5

Handout 1



The Tree of ELT (Hutchinson & Waters, 1987, p. 17)

Appendix 6

Lesson Plan (2)

Scientific Writing

Tutor: Ms. Kaouther BOUDJEMAA **Date:** November 2016
Learners: PhD Chemistry Students **Duration:** 2 Hours

Aims:

- To familiarise the learners with the different characteristics of scientific writing.
- To highlight the importance of audience in scientific writing.

Steps:	**Procedure:**	**Objectives:**
Introduction	- Quick summary of the previous lesson: EST is the specific use of English in the fields of science and technology. This specific use requires distinct features, which make scientific writing different from any other type of writing.	➢ To lead in the students into the lesson and remind them of the previous one.
Presentation	We have seen that the use of the language in science is different from its use in other domains. So, what are the characteristics that make it different? (1) The first criterion (that even you have noticed and mentioned earlier) is **the economy of language** which is the opposite of padding (lengthening a piece of writing with unnecessary materials); i.e., in English -especially in science- an idea is (preferably) expressed in few words or in only one sentence unlike other languages. This feature makes English a better language to express science in reading and in writing: - In reading: in a scientific text written in English, you can quickly find the information you need and easily understand what was communicated. - In writing: you can convey what you want to communicate exactly and without a need to long and complex sentences and paragraphs (no redundancy, which is allowed in Arabic for example). Check the following examples which show that French uses more words than English to express the same idea: I was = J'étais What is it? = Qu'est ce que c'est? I may do it = Il se peut que je le fasse What's up? = Qu'est ce qu'il y a de nouveau? Today = Aujourd'hui This criterion helps you achieve **preciseness** which means to say only what is important and in the	➢ To state the major characteristics of scientific discourse pointing to their importance in reading and writing.

	minimum of words possible. (2) The second feature is **clarity**. Scientific communication needs to be clear, exact and simple so that the reader understands directly what is meant and what is communicated; i.e., say only what you mean because being clear helps avoiding ambiguity (more than one possible interpretation for one utterance) which is not encouraged in writing. -It is important to mention that, expressions such as "*Everyone knows that* ...", "*It is obvious* ...", "*It can be assumed* ...", "*clearly/obviously*..." are not accepted in scientific writing. (you are supposed to state facts and what is obvious for you might not be obvious for the readers) (3) Science -in most cases- is totally dependent from the scientist, i.e. the same experiment or investigation can be done (repeated) by any other scientist. Therefore, scientific work demands **objectivity** (already seen last time). _When it comes to science writing, objectivity can be achieved through avoiding the use of personal pronouns and expressions such as: *I, my, our, my opinion, I think, I believe* …	
***Audience**	We continue with writing scientific papers: in addition to the criteria mentioned earlier, another important factor that should be taken into consideration is "audience". During the writing process, you should know who is going to read your papers. Knowing audience helps the writer achieve *clarity* and *objectivity*. It is also useful to know whom you are writing to in that it determines the type of information you have to include. **e.g.** if you are writing a paper that is going to be read by peer-scientists of the same field as you, then you do not have to include unnecessary information: commonly obvious/known facts, definition of known items … However, if the target audience is students or the general public, then every single detail is important. ➔ This leads us to distinguish three types of audience: - Peers: experts in the same field. - Trainee scientists: students who are not (yet) familiar with everything in the field. - General public: not scientists (at least not in the same field) but people who are curious about the subject and new achievements in science and might require full explanations (such as media, businessmen, enterprises, etc.) ➔ Before or while writing, you have to ask	➢ To emphasise the role of the audience of scientific articles and the importance of recognising your audience in writing.

	yourself the question: “who am I writing for?” If your audience is not known to you, then you can imagine it.	

Feedback

- Students have already seen texts about the same ideas written both in French and in English and noticed the difference in length.
- They have also observed the difference in “the degree of difficulty” between texts written to peers and others written to the general public (usually about the same topic): “a lot of jargon, fewer explanations, non-verbal modes” dominate the peer texts.

Appendix 7

Lesson Plan (3)

The Scientific Article

Tutor: Ms. Kaouther BOUDJEMAA
Learners: PhD Chemistry Students

Date: January 2017
Duration: 2-3 Hours

Aim:

- To provide the students with a practical guide to writing a scientific article: the form (mainly the IMRaD layout).

Materials:
- Handouts:
Providing extra tips

Steps	Procedure	Objectives
Introduction (lead-in)	We have been discussing *scientific writing* so far. What are you supposed to write in English? (Your theses are going to be written in French). The answer is "scientific articles" (SA). So, what is a scientific article? -The *scientific article* is an academic paper that (usually) summarises the results (and how they are achieved) of an experiment or any other scientific activity. This paper is -generally- aimed to be published. -A scientific article is a technical document that describes a significant experimental, theoretical or observational extension of current knowledge, or advances in the practical application of known principles. (O'conner & Woodford, 1976) In science, the article explains: the observation of the scientist, reference to the previous theories and researches which are already achieved about this observation -if any-, and the experiment being hold to test/check this observation.	➢ To direct the students' attention towards the articles. ➢ To check students' background knowledge of the scientific article. ➢ To provide an operational definition of the scientific article.
Presentation	**Format:** Most articles written and published in nature sciences follow a standard -universal- format. You all know it as the IMRaD format (or simply IMRD) that stands for: Introduction, Methods and Materials, Results and Discussion. These are the core components of a research article. [in some guides, you may find it as: AIMRaD which includes the Abstract as a key component] However, they are not the only ones. Other parts are also as important and must be available in any SA such as: Title, Abstract, Conclusion, Bibliography, etc. *Let's see briefly what each of the components requires to be accepted in SA. **1) Title and Abstract:** Sometimes they are the only read or published	➢ To state briefly the components of the scientific article ➢ To highlight the necessary details in each of the sections

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<td>sections, or the only parts that are accessible in most journals.
Title: its importance lies in the fact that it is your first communication with the reader; i.e., it is the first item to be read (the first part that appears when searching about related topics) and so, it gives an impression about the whole work. The title must explain what the paper is about. It is your first opportunity to attract the readers' attention.
Therefore, writing the title of a scientific article needs serious thought and consideration.
There are some criteria that should be taken into consideration when writing the title:
"it needs to be simple, direct, accurate, appropriate, specific, functional, interesting, attractive / appealing, concise / brief, precise / focused, unambiguous, memorable, captivating, informative (enough to encourage the reader to read further), unique, catchy, and it should not be misleading." (Moss, 2004) i.e., it should contain enough details to introduce the work and attract the interest of readers, and also get the paper to be cited more frequently.
A title can be: Noun phrase, Statement or Question
*Noun phrase titles are very effective: brief, informative, and with keywords placed near the front. However, it sometimes does not appear to be complete.
E.g.
X Evidence of Involvement of Proteinaceous Toxins from Pyrenophora Teres in Tet Blotch of Barley
→ In this case, a complete sentence is better:
√ Proteinaceous Metabolites from Pyrenophora Teres Contribute to Symptom Development of Barley Net Blotch. (Sarpeleh et al. 2007)
* Sometimes a question is used:
Which Insect Introductions Succeed and which Fail?
(not frequent but possible)*
On the other hand, there is a list of what should be avoided in SA titles along with examples of titles to study. (Handout 3.1.)
Abstract:
-It provides a brief summary of each of the main sections of the paper. It can be self-explanatory without reference to the paper, but it is not a substitute for the paper. (it is dependent on the article and it does not contain all details; reference to other parts of the paper is required to have enough information)
-A well-prepared abstract enables readers to know the content of a paper quickly and accurately to determine its relevance to their interests, and thus to decide whether they need to read the entire paper or not.
-A good abstract should be "accurate, self-contained, concise and specific, non-evaluative, coherent and readable". (APA, 1994) [= correct and exact, complete in itself, brief, concerned only with facts, clear and</td>
<td>and how it must be written.

➢ To recognise the necessary criteria of writing a good title.

*Capitalisation in titles is explained here.

➢ To underline the main characteristics of a valuable abstract.</td>
</tr>
</table>

	comprehensible] -The abstract then, like the title, must be attractive because it is the reason why others would read and refer to your article. (It is followed by a short list of the key words/phrases) It should reflect the important elements of the Scientific Article: *the objective of the study, the followed methods, the results and the conclusions -findings- derived from them*. All these data must be included in one coherent paragraph. Therefore, it is the last section to be written. The components of an Abstract are summarised as follows: **B=** Some background information **P=** The principal activity (or purpose) of the study and its scope **M=** Some information about the methods used in the study **R=** The most important results of the study **C=** A statement of conclusion or recommendation (Handout 3.2. contains a brief explanation of the necessary details in the abstract and provides a comparison between bad and good abstracts on several levels) **2) The IMRaD Sections:** ***Introduction** (What are you studying and why?) If you want others to cite your paper, you should make sure they read it first. Let us assume that the title and the abstract of your paper have convinced your peers that they should see your paper. It is then the job of the Introduction to ensure that they start reading it and keep reading it, to pull them in and to show them around as it were, guiding them to the other parts of the paper. The Introduction should answer the question 'Why': why you choose that topic for research; why it is important; why you adopted a particular method or approach, and so on; i.e., to explain the purpose of the study. It puts the study in its context with reference to previous studies. Then, specify the objectives of the experiment or analysis of the study described in the paper. (Handout 3.3. contains an approach to writing a scientific paper's introduction) ***Methods and Materials** (What did you do?) In some journals: Methodology While the Introduction answers the question WHY, the Methods and Materials section answers the question HOW. The Methods section is mainly written to provide the information needed for another scientist to repeat the work. However, this is not the only reason. This section establishes credibility for the results and should therefore provide enough	➢ To cover some quick tips on writing each of the sections and the necessary details that must be included in them.

	information about how the work was done (for readers to evaluate the results). (details such as: source of material, equipment, quantities, duration, etc.) -The Methods section of an ideal manuscript aims to share the scientific knowledge with transparency and also establishes the robustness of the study. -you can start writing your article from this section. -it is descriptive, yet not easy to be written because of its highly technical nature. -you have to make this section clearly connected to the Results (you can use one of these strategies: **-Strategy 1** Use identical or similar subheadings in the Methods and the Results sections. **-Strategy 2** Use introductory phrases or sentences in the Methods that relate to the aims. (Handout 3.4. contains useful tips on how to write an appropriate Methods section) *__Results__ (What did you find?) We have already said that the Introduction answers the question **WHY**, the Methods and Materials section answers the question **HOW**, the Results section answers the question **WHAT …** The Result section is the key driver of your article; it is where you report the findings of your study based upon the information gathered as a result of the methods you applied. It should simply state the findings, without bias or interpretation, and must be arranged in a logical sequence. Make clear: -which data to include; -what are the significant points that form the story of the paper; and -what is/are the take-home message(s). -decide which parts are going to be illustrated with figures and which data are to be presented in tables. *In writing the Results*: be concise in using non-textual elements, such as figures and tables, to present results more effectively. Decide what material that would normally be included in a research paper from any raw data or other material that could be included as an appendix. (sometimes the journal you submit your paper to has clear restrictions on whether to include tables and figures within the text of the section or to put them separately in Appendices). Reference to these visuals must be clear in the text [in numbered order, e.g., Table 1, Table 2; Chart 1, Chart 2]. -For most research paper formats, there are <u>two</u> ways of presenting and organising the results. 1. **Present the results followed by a short explanation of the findings**. For example, you may have noticed an unusual correlation between two variables during the analysis of your findings. It is	

	correct to point this out in the results section. However, speculating as to why this correlation exists, and offering a hypothesis about what may be happening, belongs in the discussion section of your paper. 2. **Present a section and then discuss it, before presenting the next section then discussing it, and so on**. This is more common in longer papers because it helps the reader to better understand each of findings. In this model, it can be helpful to provide a brief conclusion in the results section that ties the findings together and links them to the discussion. (Handout 3.5. contains diagrams of the two possible organisations of the Results and Discussion sections in addition to questions useful to outline this section) -The content of your Results section, in general, should include the following elements: 1. An introductory context for understanding the results by restating the research problem that underpins the purpose of your study. 2. A summary of your key findings arranged in a logical sequence that generally follows your methodology section. 3. Inclusion of non-textual elements, such as, figures, charts, photos, maps, tables, etc. to further illustrate the findings, if appropriate. 4. In the text, a systematic description of your results, highlighting observations that are most relevant to the topic under investigation. 5. The page length of your results section is guided by the amount and types of data to be reported. However, focus only on findings that are important and related to addressing the research problem. ***Tables and Figures:** Tables and figures should stand alone: that is, the reader should not need to consult the text of the article to understand the data presented in the table or figure; all necessary information should appear in the table/figure, in the title/legend. Which is better: table or figure? Depends on the data you want to present **Tables are most useful for:** - recording data (raw or processed data); - explaining calculations or showing components of calculated data; - showing the actual data values and their precision; and - allowing multiple comparisons between elements in many directions. **Figures are most useful for:** - showing an overall trend or ‘‘picture’’;	

	- comprehension of the story through ‘‘shape’’ rather than the actual numbers; and - allowing simple comparisons between only a few elements. (Additional details about figures and tables are in Handout 3.6.) *__Discussion__ (What do your findings mean?) … and the Discussion answers the question SO WHAT At this stage of your writing, you interpret the results, discuss them and explain them. Describe the significance of the findings. A good Discussion extends the specific results to their broader implications, which can then be tied in with the general background given in the introduction to maximize the impact of the overall paper. Therefore, you have to read carefully through the paper from top to bottom to make your paper coherent and legible. When writing the Discussion, put these points in your mind: **DOs:** • Start by stating whether your hypothesis was supported • Interpret the results: what do the results imply? • Relate your findings to those of previous studies, for example, whether your results support or deviate from results in previous studies • Explain how the study adds to previous knowledge • Remember to mention any possible alternative explanations for the results • Address the limitations of the study **DON’Ts:** • Don’t simply repeat the results again and do not include new results • Don’t draw conclusions that are not supported by the data • Don’t use jargon here too • Don't be subjective in your interpretation: every explanation is supported with data (however, you can engage in creative thinking about issues through evidence-based interpretation of findings) **3) Other Sections:** *__Conclusion__ (What have you learned from the study?) The conclusion is also important because it states the major answer to the main question/problem in the paper. It puts the main conclusions of the study in the context of the formulated problem. By the time readers reach this part of the text, they should have understood the work and the outcomes of the research. Readers should be able to understand how and why you reached your conclusions and why your research should matter to them.	➢ To present -briefly- the other possible sections that essentially exist in scientific articles

	The Conclusion should present the last word on the issues you raised in your paper. **DOs:** • Explain what you've learned from the study • Ensure that the conclusion is directly related to your research question and stated purpose of the study • Elaborate on the broader implications of the research • Suggest specific future avenues of research to advance the knowledge you've gained from the study or answer questions that your study did not address **DON'Ts:** • Don't simply summarize the results • Don't overgeneralize the results, that is, stretch the study findings to provide suggestions or conclusions that the research doesn't really support *__References/Works Cited:__ This section includes all the references to items cited within the body of the article. The referencing style is usually requested by the journal. ***Appendix (-ices):**, An appendix contains material that is appropriate for enlarging the readers' understanding, but that does not fit very well into the main body of the paper. Such material might include tables, charts, summaries, questionnaires, interview questions, lengthy statistics, maps, pictures, photographs, lists of terms, glossaries, survey instruments, letters, copies of historical documents, and many other types of supplementary material. (after the main body of your paper and before the References) *__Acknowledgments:__ enable you to thank all those who have helped in carrying out the research. This is a list of common expressions used in the acknowledgments: ✓I would like to express my very great appreciation to *** ✓I would like to offer my special thanks to *** ✓Advice given by *** has been a great help in *** ✓I am particularly grateful for the assistance given by *** ✓Assistance provided by *** was greatly appreciated. ✓I wish to acknowledge the help provided by *** ✓Dr *** provided me with very valuable ***	

Feedback	- The students found this lesson very useful. They became aware of the necessary details to be put in each section of their articles and how they are related.

Appendix 8

Handout 3.1.

Scientific Article: Title

A Handy List of Don’ts

What should be avoided in the title of SA:

- The period generally has no place in a title (even a declarative phrase can work without a period)
- Likewise, any kind of dashes to separates title parts; however, hyphens to link words is accepted
- Chemical formula, like H_2O, CH_4, etc. (instead use their common or generic names)
- Avoid roman numerals (e.g., III, IX, etc.)
- Semi-colons ; (the colon, however, is very useful to make two-part titles)
- The taxonomic hierarchy of species of plants, animals, fungi, etc. is not needed
- Abbreviations (except for RNA, DNA which is standard now and widely known) for they confuse readers
- Initials and acronyms (e.g., “Ca” may get confused with CA, which denotes cancer)
- Avoid question marks (this tends to decrease citations)
- Uncommon words: a few are okay, but too many can confuse readers (especially non-peers)
- Numerical exponents, or units (e.g. km^{-1} or km/hr)
- Cryptic/complex drug names (use the generic name if allowed to)
- Obvious or non-specific openings with a conjunction: e.g., “Report on”, “A Study of”, “Results of”, “An Experimental Investigation of”, etc. (these don’t contribute meaning!)
- Italics, unless it is used for the species names of studied organisms
- Shorten scientific names (not *coli*, but write instead *Escherichia coli*)
- Keep it short. Aim for 50 to 100 characters, but not more (shorter titles are cited more often) or less than 13 words

Examples of titles with comments/remarks on the content and number of words:

Title:	Comments:
A Prospective Antibacterial Utilization Study in Pediatric Intensive Care Unit of a Tertiary Referral Center	Optimum number of words capturing the main theme; site of study is mentioned
Study of Ventilator-Associated Pneumonia in a Pediatric Intensive Care Unit	The words “study of” can be deleted
Benzathine Penicillin Prophylaxis in Children with Rheumatic Fever (RF)/Rheumatic Heart Disease (RHD): A Study of Compliance	Subtitle used to convey the main focus of the paper. It may be preferable to use the important word “compliance” in the beginning of the title rather than at the end. Abbreviations RF and RHD can be deleted as corresponding full forms have already been mentioned in the title itself
Neurological Manifestations of HIV Infection	Short title; abbreviation “HIV” may be allowed as it is a commonly used abbreviation
Krabbe Disease - Clinical Profile	Very short title (only four words) - may miss out on the essential keywords required for indexing
Experience of Pediatric Tetanus Cases from Mumbai	City mentioned (Mumbai) in the title - one needs to think whether it is required in the title
Atresia of the Common Pulmonary Vein - A Rare Congenital Anomaly	Subtitle used to convey importance of the paper/rarity of the condition
Psychological Consequences in Pediatric Intensive Care Unit Survivors: The Neglected Outcome	Subtitle used to convey importance of the paper and to make the title more interesting

- The choice of the keywords to be included in the Title are important:

X Effects of added calcium on salinity tolerance of tomato

→ The nature of the effect is not clear whether positive or negative.

√ Calcium addition improves salinity tolerance of tomato

→ The effect is “improvement”.

Checklist/useful tips for drafting a good title for a research paper:

The title needs to be simple and direct

It should be interesting and informative

It should be specific, accurate, and functional (with essential scientific “keywords” for indexing)

It should be concise, precise, and should include the main theme of the paper

It should not be misleading or misrepresentative

It should not be too long or too short (or cryptic)

It should avoid whimsical or amusing words

It should avoid nonstandard abbreviations and unnecessary acronyms (or technical jargon)

Title should be SPICED, that is, it should include Setting, Population, Intervention, Condition, End-point, and Design

Place of the study and sample size should be mentioned only if it adds to the scientific value of the title

Important terms/keywords should be placed in the beginning of the title

Descriptive titles are preferred to declarative or interrogative titles

Authors should adhere to the word count and other instructions as specified by the target journal

Appendix 10

Handout 3.2.

Abstract

1. Elements of an Abstract

The following elements need to be properly balanced with regard to the content under each part:

- *Background and/or Objectives:* state why the work was undertaken (usually written in just a couple of sentences) +The hypothesis, study question and the major objectives.
- *Methods:* state what was done, and give essential details of the study design, setting, participants, blinding, sample size, sampling method, intervention/s, duration and follow-up, research instruments, main outcome measures, parameters evaluated, and how the outcomes were assessed or analysed (briefly)
- *Results/Observations/Findings:* (longer than the other parts) state what was found, and mention important details including the number of study participants, results of analysis (of primary and secondary objectives), and include actual data (numbers, mean, median, standard deviation, values, etc.).
- *Conclusion(s):* "The take-home message" (the "so what" of the paper) and other significant findings should be stated here, considering the interpretation of the research question/hypothesis and results put together (without over interpreting the findings).

Notes:

-Abbreviations should be avoided in an abstract, unless they are conventionally accepted or standard.

-References, tables, or figures should not be cited in the abstract.

2. Comparing Abstract Features

Some notable differences between good and bad abstracts that could help you when writing yours.

Features	Bad Abstract	Good Abstract
Length	- Too short and readers won't know enough about your work; too long and it may be rejected by the journal.	- Depending on the journal's requirements, 200 words is short enough for readers to scan quickly but long enough to give them enough information to decide to read the article.
Structure	- Jumping from point to point with no clear flow will confuse your readers.	- Follow the structure of your paper: summarize the background, motivation, methods, results, conclusion, and impact. Some journals require this to be broken down into sections, so check the Guide for Authors.
Content	- Focusing on the wrong information, such as too much content about others' work, will put off readers	- Pick the pertinent points. The content of the abstract should reflect the most important points and main findings presented in your article. This ensures it reflects your work accurately, attracting the right readers.
Style	- A badly written abstract will confuse or turn off readers, who will not want to read a badly written article.	- Clear, concise, careful writing will help readers understand the information quickly and enjoy reading it.
Language	- Too much jargon makes an abstract difficult to read and even harder to understand.	- An abstract that is accessible to a wider audience – one that contains no jargon – will encourage researchers from other disciplines to read the article.
Conclusion	- A weak – or worse, no – conclusion does not reflect the impact and importance of the work.	- A strong, clear conclusion presented near the end of the abstract shows readers the research, in a nutshell, helping them decide to read on.
Keywords	- Too few keywords in the abstract means the article is difficult to find in searches.	- Optimizing your abstract for search engines by using the most important keywords from your research helps make it discoverable for the right readers.

Checklist/useful tips for formulating a good abstract for a research paper

It should be informative and cohesive

It should be independent and stand-alone/complete

It should be concise, interesting, unbiased, honest, balanced, and precise

It should not be misleading or misrepresentative; it should be consistent with the main text of the paper (especially after a revision is made)

It should utilize the full word capacity allowed by the journal so that most of the actual scientific facts of the main paper are represented in the abstract

It should include the key message prominently

It should adhere to the style and the word count specified by the target journal (usually about 250 words)

It should avoid nonstandard abbreviations and (if possible) avoid a passive voice

Authors should list appropriate “keywords” below the abstract (keywords are used for indexing purpose)

Appendix 10

Handout 3.3.

Introduction

How to write a good introduction for a scientific paper:

1. Provide background information and set the context.

This initial part of the Introduction prepares the readers for more detailed and specific information that is given later. The first couple of sentences are typically broad.

→ **Below are some examples:**

- A paper on organic matter in soil can begin thus: 'Sustainable crop production is a function of the physical, chemical, and biological properties of soil, which, in turn, are markedly affected by the organic matter in soil.'
- A paper that discusses the possible beneficial role of bacteria in treating cancer can begin as follows: 'The role of bacteria as anticancer agent was recognized almost hundred years back.'
- A paper on lithium batteries can introduce the study with the following sentence: 'The rapid growth of lithium ion batteries and their new uses, such as powering electric cars and storing electricity for grid supply, demands more reliable methods to understand and predict battery performance and life.'

Note: At the same time, the introductory statement should not be too broad: note that in the examples above, the Introduction did not begin by talking about agriculture, cancer, or batteries in general, but by mentioning organic matter in soil, the role of bacteria, and lithium ion batteries.

2. Introduce the specific topic of your research and explain why it is important.

As you can see from the above examples, the authors are moving toward presenting the specific topic of their research. So now in the following part, you can bring in some statistics to show the importance of the topic or the seriousness of the problem.

→ **Here are some examples:**

- A paper on controlling malaria by preventive measures, can mention the number of people affected, the number of person-hours lost, or the cost of treating the disease.
- A paper on developing crops that require little water can mention the frequency of severe droughts or the decrease in crop production because of droughts.
- A paper on more efficient methods of public transport can mention the extent of air pollution due to exhausts from cars and two-wheelers or the shrinking ratio between the number of automobiles and road length.

3. Mention past attempts to solve the research problem or to answer the research question.

You indicate any earlier relevant research and clarify how your research differs from previous attempts. The differences can be simple: you may have repeated the same set of experiments but with a different organism, or elaborated (involving perhaps more sophisticated or advanced analytical instruments) the study with a much larger and diverse sample, or a widely different geographical setting.

→ **Here are two examples:**

- 'Although these studies were valuable, they were undertaken when the draft genome sequence had not been available and therefore provide little information on the evolutionary and regulatory mechanisms.'
- 'Plant response is altered by insect colonization and behaviour but these aspects have been studied mostly in sole crops, whereas the present paper examines the relationship between crops and their pests in an intercropping system.'

4. Conclude the Introduction by mentioning the specific objectives of your research.
The earlier paragraphs should lead logically to specific objectives of your study. Note that this part of the Introduction gives specific details. For instance, specify what methods of control were used and how they were evaluated. At the same time, avoid too much detail because those belong to the Materials and Methods section of the paper.

→ **Here are two more examples:**

- ‘this study aimed to assess the effectiveness of four disinfection strategies on hospital-wide incidence of multidrug-resistant organisms and *Clostridium difficile*’
- ‘the current investigation aimed (1) to assess the epidemiological changes before and after the upsurge of scarlet fever in China in 2011; (2) to explore the reasons for the upsurge and the epidemiological factors that contributed to it; and (3) to assess how these factors could be managed to prevent future epidemics.’

Note: to construct the objectives: questions, hypotheses an infinitives are frequently used.

Examples: *Questions*

- ‘Do some genes in wheat form gene networks? If they do, to what extent as compared to rice?’

  Hypotheses

- ‘The current study aimed to test the following two hypotheses related to employees of information-technology companies:

  H1: Career stages influence work values.

  H2: Career stages influence the level of job satisfaction.’

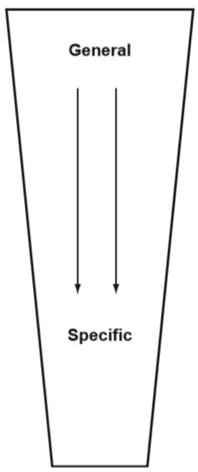
  Infinitives

- ‘To examine the response of *Oryza sativa* to four different doses of nitrogen in terms of 1) biomass production, 2) plant height, and 3) crop duration.’

+ One more tip: although the Introduction is the first section of the main text of your paper, you do not have to write that section first. You can write it, or at least revise it, after you have written the rest of the paper: this will make the Introduction not only easier to write but also more compelling.

42

When and how to write each section



1. Statements about the field of research to provide the reader with a setting or context for the problem to be investigated and to claim its centrality or importance.
2. More specific statements about the aspects of the problem already studied by other researchers, laying a foundation of information already known.
3. Statements that indicate the need for more investigation, creating a gap or research niche for the present study to fill.
4. Statements giving the purpose/ objectives of the writer's study or outlining its main activity or findings.
5. Optional statement(s) that give a positive value or justification for carrying out the study.

Fig. 8.1 Five stages of an Introduction to a science research article (after Weissberg & Buker 1990).

Appendix 11

Handout 3.4.

Methods and Materials

Some tips to write an interesting and informative Methods section:

1. Break ice between the readers and the Methods section

The names of the reagents/substances and instruments, with some numbers in terms of some concentrations, or the technical terminologies in the Methods section of an article make the reading a heavy piece of text. This can be avoided through:

- **Explanation**: explain the choice and employment of certain materials and methods (over others).
- **Visual presentation**: the schematic diagrams, flowcharts, and tables can be used to provide clarification of the data presented.

2. The DOs and DON'Ts of writing the Methods section

2.1. DOs

A. Adhere to the specific guidelines: Some journals have specific restrictions. For example, the heading of this section can differ from one journal to another between "Methodology" and "Methods and Materials".

B. Structure the section so that it tells the story of your research: All the experiments should be presented in a logical manner that helps the reader retrace the gradual, development, and nuances of the study. A useful way of achieving this is to describe the methods in a chronological order of the experiments.

C. Follow the order of the results: To improve the readability and flow of your manuscript, match the order of specific methods to the order of the results that were achieved using those methods.

D. Use subheadings: Dividing the Methods section in terms of the experiments helps the reader to follow the section better. You may write the specific objective or the name of each experiment/step as a subheading.

E. Provide all details meticulously: Provide the details that you considered while designing the study or collecting the data because the smallest variations in these steps may affect the results and interpretation of their significance.

F. Specify the variables: Clearly mention not only the control variables, independent variables, dependent variables but also if there were any extraneous variables that might influence the result of your study.

2.2. DON'Ts

A. Do not describe well-known methods in detail: For the sake of brevity, avoid listing the details of the experiments that are widely used or already published in numerous articles in your field of research. However, if you have modified the standard process to meet the specific aim of your study, do describe the modifications and the reasons for those in sufficient detail.

B. Do not provide unnecessary details: Avoid unnecessary details that are not relevant to the result of the experiment. Try to stick only to the details that are relevant and have an impact on your study.

C. Do not discuss the pros and cons of other methods: Utilize the Methods section only to mention the details of the methods you chose.

Appendix 12

Handout 3.5.

Results

There are two possible structures of a research article, which differ in the position of the *Discussion* according to the *Results*:
*a summary of the main features to focus on in each section.

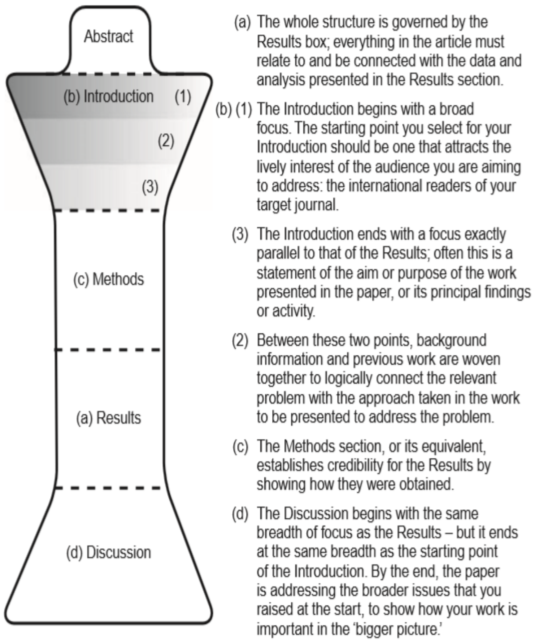
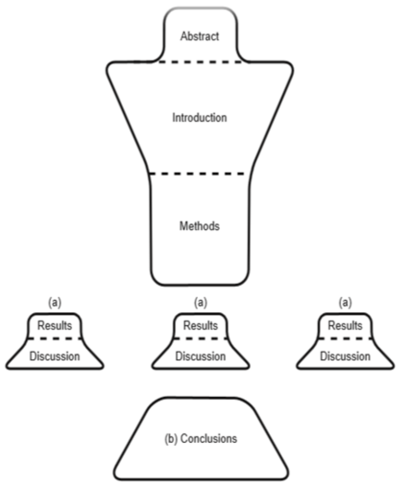


Fig. 2.1 AIMRaD: the hourglass "shape" of a generic scientific research article and key features highlighted by this shape.



(a) The Results and Discussion are presented together in a single combined section; each result is presented, followed immediately by the relevant discussion.

(b) This change means that a separate section is needed at the end to bring the different pieces of discussion together; it is often headed Conclusions.

Fig. 2.3 AIM(RaD)C (Abstract, Introduction, Materials and methods, repeated Results and Discussion, Conclusions): a structure variation that is permitted in some journals, usually for shorter articles.

The following questions help you outline and draft your result section:

1- *What do my results say?* (Two sentences maximum, a very brief summary of the main points, no background!)

2- *What do these results mean in their context?* (i.e. what conclusions can be drawn from these results?)

3- *Who needs to know about these results?* (i.e. who specifically forms the audience for this paper you are going to write?)

4- *Why do they need to know?* (i.e., what contribution will the results make to ongoing work in the field? Or, what will other researchers be missing if they haven't read your paper?)

- When writing the Results section, avoid doing the following:

≠ *Discussing or interpreting your results* (leave this for the Discussion section)

≠ *Reporting background information or attempting to explain your findings* (this was in the Introduction)

≠ *Ignoring negative results* (If some of your results fail to support your hypothesis, do not ignore them. Document them, then state in your discussion section why you believe a negative result emerged from your study)

≠ *Repeating data* in text and tables.

Appendix 13

Handout 3.6.

Figures and Tables

1. Table or Figure:

The following table below provides quick points that help you choose between data display in figures or tables:

Most useful	**Table**	**Figure**
-When working with:	Number	Shape
-When concentrating on:	Individual data values	Overall pattern
-When accurate or precise actual values are:	More important	Less important

(Cargill & O'Connor, 2009, p.24)

2. Figures:

Design each figure around the point you want to get across most strongly.

It may be helpful to determine the design elements you want in the figure before going to the graphics package.

In designing your figures you may consider things such as:

- which variable needs to have the most prominent symbol or line;

- whether you want to emphasize differences or similarities between elements; and

- what scale, scale intervals, maximum and minimum values, and statistical representations are most meaningful.

The range of common figure types listed below allows you to emphasize different qualities of the data.

Pie charts are effective at highlighting proportions of a total or whole.

Column and bar charts are effective for comparing the values of different categories when they are independent of each other (e.g. apples and oranges).

Line charts allow the display of a sequence of variables in time or space or the display of other dependent relationships (e.g. change over time).

Radar charts are useful when categories are not directly comparable.

You should also be consistent with styles of figures throughout the article. It is especially important to keep the same symbols and order for given treatments or variables in all figures if possible.

Avoid the following:

-data already shown in the text or tables are repeated in the figure

-the figure is unnecessarily cluttered with lines, legend symbols, numbers, or poorly chosen axis scale divisions

-axes are not labelled descriptively or are labelled with the jargon of the scientific sub-discipline

-numbers are included when the exact values are not important to the story and the approximate values can be derived from the x and y axes

An example of a corrected figure is shown below:

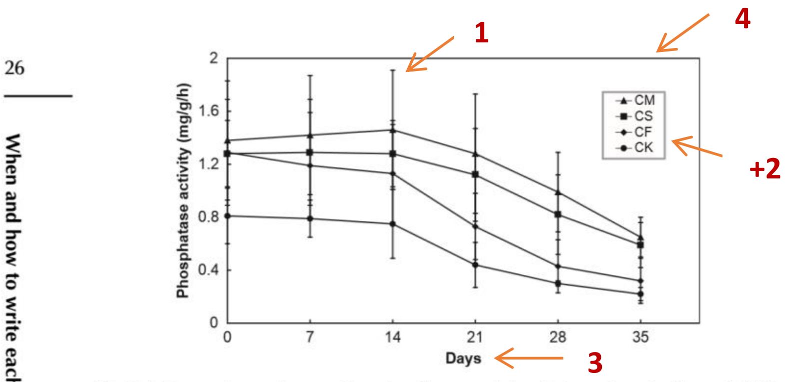


Fig. 5.1 Comparisons of root surface phosphatase activity of wheat plants for Control (CK), exclusively chemical fertilizer (CF), combined application of chemical fertilizer and wheat straw (CS), and farmyard manure (CM) treatments. Error bars represent the standard error of the mean for each treatment.

2

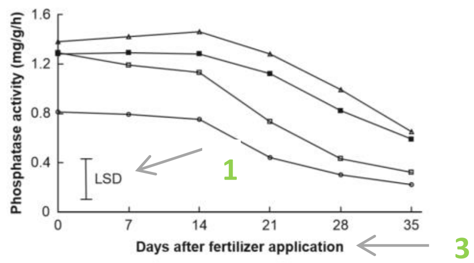


Fig. 5.2 Root surface phosphatase activity of wheat plants differed after soil amendment with different fertilizer treatments. Phosphatase activity was highest in farmyard manure (▵) treatments followed by combined application of chemical fertilizer and wheat straw (■), chemical fertilizer alone (□), and control/no amendment (○) treatments. Phosphatase activity declined over 5 weeks for all treatments. Least significant difference (LSD; two-way ANOVA, $P \leq 0.05$) is 0.39 mg/g/h.

2

1 → Removal of error bars and replacement with LSD bar decreases clutter= allows comparison of significant differences between treatments and allows the Y axis to be expanded with a lower maximum (i.e. greater spread between the lines).

2 → More detail about the significance level of difference is also provided in the figure legend.

+2 → Describing symbols in the figure legend instead of using an inserted legend leaves more white space to help readers compare the lines. (Sometimes the figures are so small and inserted legend can be unclear)

3 → The X axis is more descriptively titled

4 → The removal of the figure border also reduces clutter in this line graph.

3. Tables:

Tables are often used to:

- record data and meta-data of a study and may contain a number of rows or columns.
- communicate large amounts of information more efficiently.

Tables need good design, layout, choice of data for inclusion, ordering of data within the table, clear and informative row/column headings and table title and defined abbreviations in the title.

Avoid the following:

- inclusion of unnecessary or redundant data (e.g. data that are not referred to in the text and do not contribute to the text)
- omission of data necessary for the reader to make important calculations from experimental data
- table not arranged to highlight the most significant results
- data not sorted to show important relationships between elements

Tables (and figures) are supposed to provide necessary information or explain essential parts of the main text; therefore, they have to be written with conciseness and clarity. They must stand in a good shape and place, and do not cause any confusion or clutter in the paper.

Appendix 14

Lesson Plan (4)

<u>Language Features</u>

Tutor: Ms. Kaouther BOUDJEMAA **Date**: March 2017
Learners: PhD Chemistry Students **Duration**: 2-3 Hours (Each part)

Aims: - To highlight the significant and frequent language features in the scientific article writing. (To help the students proofread their papers)	**Materials:** -Handouts ° Vocabulary ° Voice ° Tenses

Steps	Procedure	Objectives
Introduction ***Style Features**	Writing scientific articles proves to be a specific process of writing which has certain aspects that must be taken into consideration. These specific details require particular language features that every science writer should take into account when writing (especially writing SA). Writing in science as seen before (in lesson 2) is different from general English and other types of writing; i.e., what is allowed in a literary text or fiction writing might be prohibited in science communication. Therefore, avoid using: ***Personal pronouns*** -in describing methods and results (mainly) or in the entire paper- (*I mixed …*; *I observed …*; *we have found …*; etc.) [note that personal pronouns as such can be allowed by some journals or preferred to the use of passive voice] ***Figurative language*** (indirect, colourful writing) is not accepted: (see the following examples) -<u>Simile</u>: *the colour of the solution turned red like blood.* -<u>Metaphor</u>: *the chemical bonding is magnetic ...* *Since time is money in this experiment, …* *These are not accepted in science because they cannot be accurately measured and this is not encouraged in science. Therefore, they must be avoided. ***Personal view/judgement*** is not also accepted; look at the statements below: - *"the experiment was exciting"*	➢ Introducing the concept of specific language features in science communication. ➢ Listing the stylistic features of science writing with examples.

	- *"the results were very interesting"* - *"this methodology was easy and we like it better than the others"* - *"the mixture of these chemicals produced a beautiful shiny substance" …* →"*Exciting*" and "*interesting*" are personal points of view, which can differ from one person (scientist) to another and this information is not at all important to be mentioned in a scientific context. →"*we like it*" and "*beautiful*" are not measurable and not necessary in the description of the steps or results of a scientific experiment, and so must be avoided. The choice of a method among others must be done over purely logical and scientific criteria, not personal! ***Clarity vs. ambiguity*** (as discussed before) the scientific text should be as clear, accurate and precise as possible. Therefore, ambiguous words, expressions and sentences may hinder this clarity and cause misinterpretation of the data presented in the paper. For example: - "*enzymatic activity suppression*" could be interpreted in two different ways, either: *suppression of enzymatic activity* or: *suppression by enzymatic activity* and is therefore ambiguous. (in such case, prepositions are useful to avoid ambiguity) - "*Hot equipment and substances affect the weight of the solution*." = not clear if both the equipment and the substances ae "hot" or only the equipment. ***Economy vs. wordiness***: One of the problems that science writers usually fall into is "wordiness"; i.e., using many useless words. Remember that in most (if not all) journals, the number of words is limited. Consider the following expression: "*It is important to be aware of the fact that* ..." = 10 words, which add no meaning to the idea being presented; and thus, eliminating this phrase entirely does not affect the meaning of the manuscript, and so, your readers absorb more quickly the scientific content. As more examples of wordiness (redundancy), the following expressions are provided by a journal reviewer: - "*In a recent study, it was determined that*" becomes "a recent study determined"	

<table>
<tr>
<td>*Language Features</td>
<td>- “Gain an understanding of” becomes “understand”
Some expressions add no meaning (even if your intention is to emphasise an idea) and can be simply eliminated, such as:
- "it must be pointed out that"
- "it is important to note that"
- "it must be mentioned that"
- "as a matter of fact / due to the fact that"
*<u>Tip</u>: Keep a word if
• it is necessary to the grammar of the sentence (preposition, auxiliary, articles, etc.)
• it is a key idea, fact, or description (important to the meaning)
____
Errors might also reduce the legibility and acceptability of your papers. That is why you have to pay attention to the choice of words and to the structure of sentences. Mistakes in the language can be simply corrected -after noticed by the referees- but they must not be numerous because many mistakes will reduce the chances of your paper to be accepted (even if the work you have done is perfect).
*Write carefully, revise and proofread your paper for language mistakes because good work in science can be refused or misinterpreted because of bad language.
Thus:
-Make sure you choose the most appropriate words and expressions to convey exactly the ideas and findings you are communicating (Handout 4.1. contains necessary details about words in scientific discourse).
-Revise the structure of your sentences: simple, compound or complex (what each structure requires including link words, punctuation, etc.); and pay attention when using the passive voice (Handout 4.2. provides useful notes about the use of active voices vs. passive voice).
-Be careful with the verb, its form and agreement with the subject (especially in the case of long subjects which are common in scientific texts). Pay attention to irregular verbs, which do not take the same form in past simple and past participle (to feed - fed /to hold - held …).
Remember that there is no comma (,) between the subject and the verb.
-Make sure you use the most suitable tenses to express the exact time and chronology (order) of the ideas and events in each part of your paper (tense</td>
<td>➢ Stating the importance of correct language use in communicating science.

➢ Providing tips to write correctly and accurately (vocabulary, tenses, sentence structure, voice and phrasal verbs)</td>
</tr>
</table>

	makes difference -sometimes-: you can express very different things when simply changing the tense). The tense, which is most appropriate to express the idea, should be used; else, the statement would express something opposite to what you wanted to state or write. Correct use of tense will imply the use of correct form of verb with proper auxiliary. (Handout 4.3. contains necessary information about tenses: form, use and importance). -Be careful when using phrasal verbs. Changing the adverb/preposition after the verb could be erroneous or would change the meaning of the verb completely. (More details and examples about phrasal verbs are provided in Handout 4.4.).	

Feedback

- The explanation of the (grammar) rules and presentation of mistakes and errors (some of the students' errors) allowed the lesson to be more vivid and interesting.

- Students appreciated the examples of words and expressions that can be replaced or omitted saying that they would like to have more of these expressions.

Appendix 15

Handout 4.1.

Vocabulary in the Scientific Discourse

Vocabulary in Science Communication:

Vocabulary in scientific texts can be classified into several types according to frequency, technicality, length, part of speech, etc. In this lesson, we are going to study the types of vocabulary classified according to the degree of technicality: technical, sub-technical and general English terms (non-technical/ordinary words). Technical and general words are not difficult and usually cause no problem unlike sub-technical terms, which are problematic and need attention.

1. The Importance of Word Choice

We have already spoken about the importance of economy and the problem of wordiness or redundancy in science writing. The number of words is limited in the Scientific Article and every word counts; therefore, you must be careful in the choice of words when writing especially when describing the most important parts of your paper. Avoid *jargon* because as mentioned earlier audience of science includes more than only peer scientists. Do not try to impress with words because you are supposed to only state facts.

There are many types of wordiness; here are some examples:

(Note: there might be exceptions)

a. Eliminate Redundancy

Redundant:	**Better:**
each separate sample	each sample
many different ways	many ways
dash quickly	dash
as to whether	whether
tall skyscraper	tall
blue in colour	blue
advance notice	notice
he is a man who is	he is
appear to be	appear
completely finished	finished
the reason . . . is because	because

b. Delete empty words and phrases:

Generally	tend to	Really
Apparently	in my opinion	Very
Basically	I think that	Various
Essentially	I feel	in some ways
Virtually	I believe	for all intents and purposes

c. Avoid expressions that can be more clearly said in another way:

at this point in time	at this time/now
had an effect upon	influenced
due to the fact that	because
in order to	to
for the purpose of	for
it is important that	must
until such time as	until
at the same time as	while
with the possible exception of	except

d. Delete the following phrases and variations:

- there is . . . that
- it is . . . that

There are many molecules that bond together.	Many molecules bond together.
It is the solution that is cooled.	The solution is cooled.

e. Use one word instead of a long expression:

"Due to the fact that" becomes "because"

"Are able to", "is able to" or "has the ability to" all become "can"

"have been found to be able to" becomes "could".

2. Types of Words in the Scientific Discourse

Not only scientific terms (jargon - terminology - technical terms: might be different but are referred to as similar here) are used in a scientific text. A complete text requires ordinary words as well, including grammatical words [articles (a, the), prepositions (to, in, for), auxiliary verbs (be, have), etc.] and -general- content words [adjectives (hot, cold), adverbs (specifically, finally), verbs (move, add), etc.]. Between these two types emerged another type known as "semi-technical words" which are ordinary in nature and technical in use.

A/ Technical Words:

Technical vocabulary refers to:

-highly specialized lexis in the subject-matter courses.

-subject related, occurs in a specialist domain, and is part of a system of subject knowledge.

-the specialized vocabulary of any field which evolves due to the need for experts in a field to communicate with clarity, precision, relevance and brevity.

Table: Examples of Chemistry-specific Vocabulary (A-Z Chemical Dictionary, 2008)

*Technical Word:	Its Meaning:
Acid	A substance that dissociates in water to produce hydrogen ions (H^+) as the only positive ions.
Alkane	Hydrocarbons having the general formula C_nH_{2n+2}
Electron	A negatively charged sub-atomic particle that surrounds the nucleus of an atom.
Ion	A positively or negatively charged particle. It is formed when an atom or group of atoms loses or gains electrons.
Titration	The gradual addition of a solution from a burette to another solution in a conical flask until the chemical reaction between the two solutions is complete.

Note: many chemical terms differ in spelling between English and French like: acid / acide; ionic / ionique; molecular formula / formule moléculaire; etc.

B/ Ordinary Words:

Represents the common words in English that are used in every text:

-Grammatical words, such as: *articles* (a/an-the), *prepositions* (on, in, at, of), *conjunctions* (and, both, or), *pronouns* (he, it, that, who, their) …

-Common content words, such as: *nouns* (water, time, thing, animal), *verbs* (be, have, do, make, know, use), *adjectives* (hot, cold, big, small), *adverbs* (always, usually, rapidly) …

C/ Semi-technical Words:

Semi-technical (sub-technical) terms are the ordinary words that occur with special meanings in specific scientific and technical fields; i.e., those words that have one or more general English meanings and which in technical contexts take on extended meanings (technical, or specialized). Sub-technical words are "constituting about 70% of technical texts" (Greavu, 2005, p. 890).

Some of these words have the same meaning in several scientific or technical disciplines (such as: *function*, *isolate*, *basis*, *stir*, *boil*, *freeze*). Others are usually common in General English but take on unusual meanings in specific scientific and technical texts.

An example is the word "base" which has a different meaning each time is used in different sciences (Trimble, 1985: 130):

Base

Botany:	The end of a plant member nearest the point of attachment to another member, usually of a different type.
Chemistry:	A substance which tends to gain a proton. A substance which reacts with acids to form salts.
Electronics:	Part of a valve [US "tube"] where the pins that fit into holes in another electronic part are located. The middle region of a transistor.
Navigation:	In a navigation chain, the line which joins two of the stations.

Note: These words are usually known in the field they are used in and do not need explanation in the text each time they are used (as noticed in your papers).

D/ Noun String:

Another frequent type of vocabulary in scientific texts is noun strings / noun compounds. A noun compound is "two or more nouns plus necessary adjectives (and less often verbs and adverbs) that together make up a single concept; that is, the total expresses a 'single noun' idea" (Trimble, 1985, pp. 103-131). Three types of noun strings can be distinguished:

1. A group of two or more nouns in addition to necessary adjectives and articles that expresses a single concept; e.g. *the heavy chemistry laboratory equipment*.
2. Compounds formed from prepositional phrases with 'of'; e.g. *the bottom of the page*.
3. Compounds formed with relative clauses (which, who, that); e.g. *a place where wheat is stored*.

Summary:

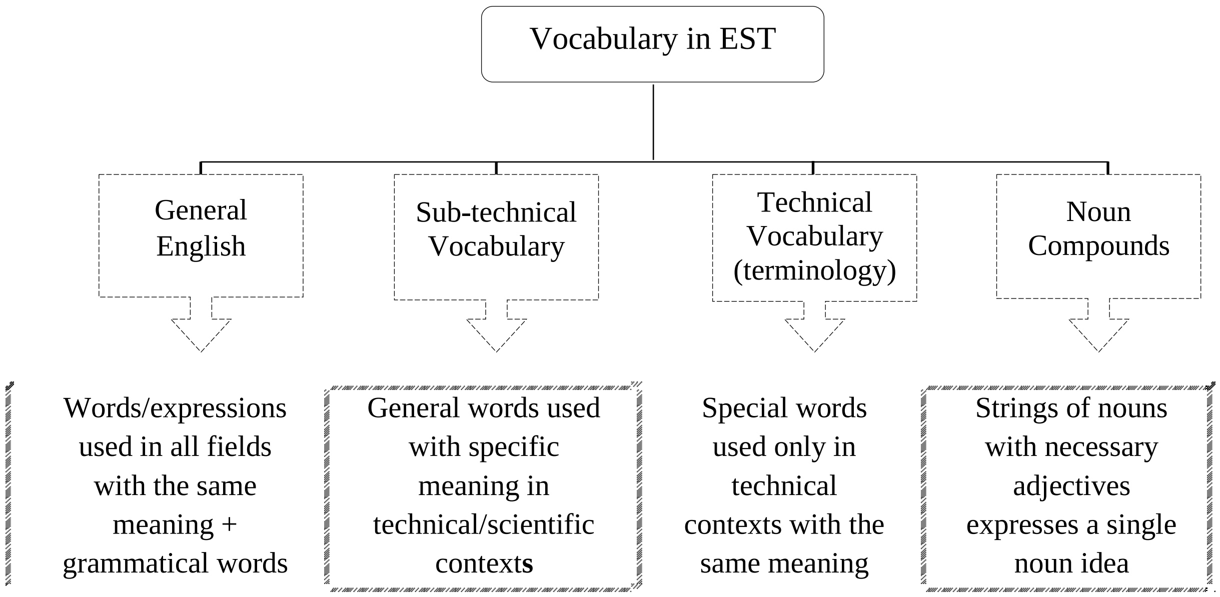


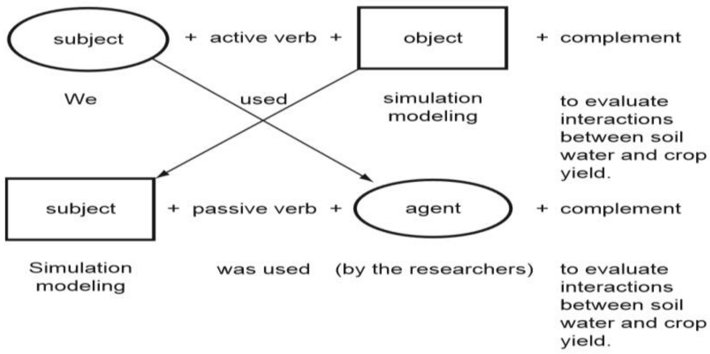
Figure 1. Types of EST Vocabulary

Appendix 16

Handout 4.2.

Active vs. Passive Voice

1. Active Voice Vs Passive Voice:
In English, the verb form, which indicates whether the subject (person or object) of a sentence do something or something has been done on the subject called the *voice*.
Uses:
- The active voice is used when it is important to mention the performer of the action [the subject is the performer of the action] (e.g., both rats received the same physical stimulation.)
- The passive voice is used when the focus is on the action (and the object) rather than the performer; and when the performer is unknown or obvious (e.g., The temperature was measured ~~*by the researcher*~~.).
Forms:
- *Active sentence* =
Subject *(doer of the action)* + Verb [in tense X] *(transitive: requires object)* + Object *(acted upon)*
- *Passive sentence* =
Subject *(the object of the active sentence)* + Verb *[**to be** (in tense X) + past participle of the verb]* + <u>by + agent (the doer of the action)</u> => (<u>optional</u>; i.e. can be removed)



Changing an active voice sentence to a passive voice sentence.

2. In Science Communication:
The students usually have the idea that in science communication, only the passive voice is allowed or it is preferred to the active voice. It is thought to be one way of achieving objectivity. However, it is proven that even scientists should avoid the passive voice -in some cases- for two major reasons: (1) using the active voice makes writing much more interesting, concise, and clear; and (2) a great deal of the noticed grammatical errors are the result of poorly constructed passive sentences. (Evans, 2015)
(**Tip**: in order to avoid errors or correct them, revise sentences in the active voice)

- Passive voice has nothing to do with scientific objectivity

Remember: eliminating passive voice is a great way to reduce your manuscript's word count.
The main argument in favour of using the passive voice in scientific writing is that it helps achieving objectivity. Maintaining objectivity is of the utmost importance in science, but the argument in favour of the passive voice is wrong for two reasons. First, when people talk about maintaining objectivity, they are really talking about avoiding the first person, which is what writers employ any time they use the pronouns *I*, *we*, *me*, *us*, *my*, or *our*. Perhaps because it's so easy to leave out the subject—*we*, for example—in a passive sentence, many people think that using the passive voice means not identifying the one doing the action.
However, active sentences need not, and usually do not, involve using the first person.
-For example, consider the following passive sentences:
1a. It has recently been found that antibodies that bind quaternary E protein might contribute to this effect.
2a. Protein was not removed from the centrosome by exposure to nocodozole.
-Here are two possible ways to place these sentences in the active voice without using the first person:
1b. Recent studies have found that antibodies that bind quaternary E protein might contribute to this effect.
2b. Exposure to nocodozole did not remove protein from the centrosome.
Whether the sentence is active or passive, it does not necessarily make the sentence objective: regardless of how one writes the sentence, the reality is that *humans were* involved in planning, conducting, and analysing the research. No amount of passive voice is going to change that. Conducting the research objectively does not mean pretending they didn't do the work, though. It simply means leaving emotion and personal biases out of the picture as much as possible and sticking to the facts.
The resulting stains were perceived as beautiful is a passive sentence. It's also totally <u>subjective</u>.
i.e. = using the first person and using the active voice are entirely different things. **It's possible to write in the active voice and still avoid the first person.**

2.1. What Qualifies as Passive Voice

In a passive sentence, the subject does not take any action. In contrast, in an active sentence, the subject does take action.

2.2. Why Using the Passive Voice is Usually *NOT* the Best Choice

Using the active voice offers several benefits, which apply as much to scientific prose as to any other.
1. Passive sentences are often needlessly long, and writing concisely improves the flow and readability of a text. For example, the active version of the following sentence removes eight words.
Passive: *The free energy released from this series of oxidation-reduction reactions is combined with production of an electrochemical gradient that can be used to drive ATP synthesis.* **(26 words)**
Active: *This series of oxidation-reduction reactions releases free energy that combines with an electrochemical gradient to drive ATP synthesis.* **(18 words)**
Remember that journal editors routinely ask authors to reduce *the word count* of their manuscripts. Rewriting sentences in the active voice would make a significant contribution toward this end.
2. Passive sentences often leave the most important information, the actor, for the end. Even worse, they do not state who the actor was at all.
- *A homerun was hit.*

- *PCM accumulation is blocked at the centrosome.*

→ Who hit the homerun? What blocked PCM accumulation?

3. It is easier to introduce grammatical errors in a passive sentence than in an active one. One frequent mistake involves describing a passive verb with active adverbs. For example:

The book was read by[1] staying up into the wee hours of the morning and drinking lots of coffee.

([1]Note that this kind of *by* is not the kind that counts as criteria for a passive sentence)

→ (The verb phrase *was read* is passive, but the adverbial phrases *by staying up* and *(by) drinking lots of coffee* are active. The sentence is therefore not parallel, and it lacks a subject to perform the actions *staying up* and *drinking lots of coffee*. It kind of sounds like the book itself was the one staying up late and drinking coffee!)

4. Studies show that people tend to have a more difficult time understanding text written in the passive voice. Readers also perceive active sentences as being more interesting.

2.3. When Passive Voice *IS* the Best Choice

There are, however, some situations in which passive voice is better or at least necessary.

1. Sometimes, the actor is unknown.

Every year, thousands of people are diagnosed with cancer.

2. Sometimes, the writer wishes to emphasize the recipient of the action rather than the actor.

Cells were treated with the drug, lysed, and stored at -20ºC.

- In conclusion, although there are plenty of times when using the passive voice creates weak writing, confusion, and errors, there are also times when we need to focus on the action.
- The passive is better used when focusing on the action and the object and not on the subject; i.e., when the subject is obvious or unnecessary to be mentioned (in Methods section, the scientists(s) is obviously the doer of most actions).
- Be thoughtful when choosing between the active and passive voice. If you have a good reason to use the passive voice, use it with intention. Otherwise, use the active voice. Your writing will be clearer and more concise, and will have a greater impact on your reader.

2.4. Which Sections of a Manuscript Require the Use of the Active Voice and Where the Passive Would be Preferable

<u>Active Voice</u>

Introduction and Discussion sections: where you discuss previous research and then introduce your own.

Example: *Previous studies have investigated contact behaviours resulting from dynamic loading. In this study, we investigated the effect of stiffness on contact behaviour.*

Notice how using the active voice in the second sentence helps the reader make a clear mental transition from previous studies to the present study. (Note that first person is allowed here)

Literature review: The literature review section of a paper often seeks to state the most important contributions in the field, which makes actors/agents/authors important.

Active: *Nobre et al. (1997) studied the surface resistance characteristics of ductile steel to affect indentation by hard alumina balls.*

Passive: *The surface resistance characteristics of ductile steel to affect indentation by hard alumina balls were studied by Nobre et al. (1997).*

→ In this case, the active voice is the best choice. It is clearer and more concise. It clearly states what the author has contributed to their article. The passive option is unnecessarily wordy and difficult to comprehend (two *by* phrases).

<u>Passive Voice</u>

Methods section: where the steps taken are more important than the doer or actor.

Active: *We obtained the velocity contour lines from CFD simulations.*

Passive: *The velocity contour lines were obtained from CFD simulations.*

→ In this case, it is more important to emphasize what was done rather than who did it; therefore, the passive voice is preferable.

Results section: The passive voice is also preferable when describing the results of a study as the presentation of results calls for objectivity.

Active: *We observed an inverse relationship between the pressure ratio and energy loss in the combustion chamber.*

Passive: *An inverse relationship was observed between the pressure ratio and energy loss in the combustion chamber.*

→ Note that in the examples above, the passive construction seems a better choice because the statement indicates that these results remain true regardless of the doer of the experiment. It adds universality to the results.

In summary, both the **active** and **passive** voices can be appropriate choices in scientific/academic writing. It is important to consider what you are trying to emphasise in a particular sentence or section of your paper. Your guiding principle should be clarity. Think about what information the target reader is looking for, and choose the active voice or the passive voice, whichever will make the text clearer and more comprehensible. If you write keeping this in mind, no journal reviewer will need to give you feedback about the active and passive voice.

Appendix 17

Handout 4.3.

Tense Use in Scientific Articles

1. Tense in English

Proper grammar is critical to make your point clear and avoid misunderstandings. One essential element of grammar is correct verb use. Verbs are words that describe actions within sentences and are crucial for strong and effective writing

The English language has three main time divisions- **Past**, **Present** and **Future** expressed by the *tenses*. Each tense is subdivided to express other aspects within its general time. Tenses form the backbone of the English language. Tenses indicate the time at which something happened. Improper usage of tenses could lead to confusion and misinterpretation of the conveyed message. For instance, the sentence "*I am reading*" has an entirely different meaning from the sentence "*I will read*". In these two sentences, while the former action is currently happening, the latter will occur at some point in the future. Thus, despite being about the same person and being about the same action i.e., reading, both sentences have taken on separate meanings merely because of a difference in tense usage. The English tenses and their forms are as follows:

Table: The English tenses and their forms

<table>
<tr><td rowspan="3">Explain: regular verb
Write: irregular verb</td><td rowspan="2">*Stem= infinitive without to</td><td colspan="4">Aspect</td></tr>
<tr><td>Simple</td><td>Continuous / Progressive</td><td>Perfect</td><td>Perfect continuous</td></tr>
<tr><td>Form:</td><td>*Stem (depends on tense)</td><td>To be + V(stem) + ing</td><td>To have + past participle</td><td>To have + been + V ing</td></tr>
<tr><td rowspan="3">Tense</td><td>Present
(stem + s)</td><td>Write / writes</td><td>Am/is/are writing</td><td>Has/have written</td><td>Has/have been writing</td></tr>
<tr><td>Past
(regular: Stem +ed)
Or irregular</td><td>Explained
wrote</td><td>Was/were writing</td><td>Had explained
Had written</td><td>Had been writing</td></tr>
<tr><td>Future
(will + stem)</td><td>Will explain
Will write</td><td>Will be writing</td><td>Will have written</td><td>Will have been writing</td></tr>
</table>

Each of the tenses has one or more specific uses. These different uses depend on the time, context and conveyed idea of the message. Table 2 below provides some of these uses.

Table: Different uses of English tenses and time indicating expressions.

Tense	Affirmative/Negative/ Question	Use	Signal Words
Simple Present	A: He speaks. N: He does not speak. Q: Does he speak?	• action in the present takes place regularly, never or several times • facts /scientific truths • actions taking place one after another • action set by a timetable or schedule	always, every …, never, normally, often, seldom, sometimes, usually if sentences type I (If I talk, …)
Present Progressive	A: He is speaking. N: He is not speaking. Q: Is he speaking?	• action taking place in the moment of speaking • action taking place only for a limited period of time • action arranged for the future	at the moment, just, just now, Listen!, Look!, now, right now
Simple Past	A: He spoke. N: He did not speak. Q: Did he speak?	• action in the past took place once, never or several times • actions took place one after another • action took place in the middle of another action	yesterday, 2 minutes ago, in 1990, the other day, last Friday if sentence type II (If I talked, …)
Past Progressive	A: He was speaking. N: He was not speaking. Q: Was he speaking?	• action going on at a certain time in the past • actions taking place at the same time • action in the past that is interrupted by another action	while, as long as
Present Perfect	A: He has spoken. N: He has not spoken. Q: Has he spoken?	• putting emphasis on the result • action that is still going on • action that stopped recently • finished action that has an influence on the present • action that has taken place once, never or several times before the moment of speaking	already, ever, just, never, not yet, so far, till now, up to now
Present Perfect Progressive	A: He has been speaking. N: He has not been speaking. Q: Has he been speaking?	• putting emphasis on the course or duration (not the result) • action that recently stopped or is still going on • finished action that	all day, for 4 years, since 1993, how long?, the whole week

		influenced the present	
Past Perfect	A: He had spoken. N: He had not spoken. Q: Had he spoken?	• action taking place before a certain time in the past • sometimes interchangeable with past perfect progressive • putting emphasis only on the fact (not the duration)	already, just, never, not yet, once, until that day if sentence type III (If I had talked, …)
Past Perfect Progressive	A: He had been speaking. N: He had not been speaking. Q: Had he been speaking?	• action taking place before a certain time in the past • sometimes interchangeable with past perfect simple • putting emphasis on the duration or course of an action	for, since, the whole day, all day
Future Simple	A: He will speak. N: He will not speak. Q: Will he speak?	• action in the future that cannot be influenced • spontaneous decision • assumption with regard to the future	in a year, next …, tomorrow If-Satz Typ I (If you ask her, she will help you.) assumption: I think, probably, perhaps
Future Simple (going to)	A: He is going to speak. N: He is not going to speak. Q: Is he going to speak?	• decision made for the future • conclusion with regard to the future	in one year, next week, tomorrow
Future Progressive	A: He will be speaking. N: He will not be speaking. Q: Will he be speaking?	• action that is going on at a certain time in the future • action that is sure to happen in the near future	in one year, next week, tomorrow

2. Effective Use of Verb Tense in Scientific Writing, mainly the Scientific Article

The meaning of a statement can completely change because of the verb tense used. For example, the following sentence, which uses present tense, tells the reader that this information is currently accepted as fact: “Antibiotic resistance *increases* over time.” However, rewriting the sentence in the past tense implies that this is the result of data collected in the past, but may not yet be accepted as a general truth: “Antibiotic resistance *increased* over time.”

Determining the correct verb tense to use can be a challenge in scientific writing, particularly when trying to differentiate previously published results from results that you obtained in your current research. Specific tenses are commonly associated with particular sections of the SA because different sections present different types of information.

2.1. Abstract

The abstract (as seen before) is a summary of the whole paper; and thus, it employs several tenses (mainly present and past) depending on the type of information being presented in each sentence.

- Use **present tense** while stating general facts

Inducible defensive responses in plants *are known* to be activated locally and systematically by signaling molecules that *are produced* at sites of pathogen or insect attacks, but only one chemical signal, ethylene, *is known* to travel through the atmosphere to activate plant defensive genes.

- Use **past tense** when writing about prior research (**present perfect** can be used)

Went's classical experiment on the diffusion of auxin activity from unilaterally illuminated oat coleoptile tips (Went 1928), *was repeated* as precisely as possible.

- Use **past tense** when stating results or observations

Determination of the absolute amounts of indole-3-acetic acid (IAA) in the agar blocks, using a physicochemical assay following purification, showed that the IAA *was* evenly *distributed* in the blocks from the illuminated and shaded sides.

- Use **present tense** when stating the conclusion or interpretations

These results *show* that the basic experiment from which the Cholodny-Went theory was derived does not justify this theory.

2.2. Introduction

Present tense is used to describe what is currently accepted as being true because it has been published in the literature.

A poor diet *increases* the risk of cardiovascular disease… (reference)

The p53 tumor suppressor *plays* a role in… (reference)

Past tense should be used to describe the methods that were used in previous publications as well as previous hypotheses that have since been disproven.

Mouse tumors *were extracted*...

The world *was thought* to be flat…

The literature review requires three tenses: the **past simple** to mention existing research about the topic and the main study in the paper; the **present simple** to express your own view (if necessary); and the **present perfect** to cite previous studies.

2.3. Materials and Methods

Past tense should be used to describe work and procedures done for the present study.

Tissue samples *were collected* from…

Transcript levels *were measured* by RT-PCR…

2.4. Results

Past tense should be used to describe the results of work and data that are being presented for the first time in the current document as well as observations and interpretations.

Overall survival *was* greater in the control group than…

Protein levels *increased* in…

The results *provided* evidence that…

Present tense should be used to describe data that is shown in figures, graphs, and tables. You may therefore have sentences that combine present and past tense verbs.

Figure 4 *indicates* that mice *treated* with drug X *survived* longer than the control mice.

2.5. Discussion

Present tense should be used to interpret results and to discuss the significance and conclusions of the study.

The data *suggest* this pathway may be responsible for…

Past tense should be used to summarise the overall findings from the research.

A new therapeutic target was *discovered* for…

Future tense should be used to convey perspectives, recommendations and plans.

In future studies, the effects of X *will be examined* ...

2.6. Conclusion

Present simple states what the researcher thinks the data mean.

The present study *demonstrates* that phototropism in radish hypocotyls *is caused* by a gradient of growth inhibition which *depends* on the light intensity through the amounts of growth inhibitor, and thus strongly *supports* the Blaauw (Blaauw 1915) hypothesis, explaining phototropism as an effect of local growth inhibition by light.

Future simple states future implications and recommendations of the study.

The influence of temperature *will be* the object of future research.

Note: Complex sentences can often be tricky because they may require the use of multiple verb tenses to accurately reflect the material presented. For instance, "In 1865, Dr. Joseph Lister *postulated* that good aseptic technique *decreases* the spread of infection." The different verb tenses are necessary in this sentence because **postulated** refers to the actions Lister took in 1865 and therefore is in past tense, while **decreases** is in present tense because it denotes a general known fact, which was derived from Lister's research.

In order to decide which verb tense to use in your writing, focus on the message that you want to convey to the reader in as clear and concise a manner as possible. Remember to pay attention to the scope and condition of the statement. Most importantly, use verb tenses as you ordinarily would in any other communication.

To summarise:

-use the **past tense** to describe what was done: the experiments conducted, the results that you obtained, etc. (**present perfect** can be used for similar purposes).

-use the **present tense** to discuss general truths and previously reported data, to provide insight, and to discuss conclusions.

-use the **future tense** for perspectives and to discuss future plans or recommendations.

3. Important to Note

Subject and verb must AGREE with one another in number (singular or plural). An easy tip that may help you remember the subject-verb agreement using the present simple tense: nouns and verbs form plurals in opposite ways:

nouns ADD an **s** to the singular form (with exceptions),

BUT

verbs REMOVE an **s** from the singular form.

This *molecule* **reacts** with pyruvic acid.	These *molecules* **react** with pyruvic acid
↑ ↑ *Singular* **Singular** -s +s	↑ ↑ *Plural* **Plural** +s -s

Consider the following rules:

1. A *phrase* or *clause* between subject and verb does not change the number of the subject. For example:

A group of two or more atoms bonds together.

The substances which reduce friction are called ...

2. *Indefinite pronouns* as subjects:

- Singular indefinite pronoun subjects take singular verbs.

Singular: *each, either, neither, one, no one, nobody, nothing, anyone, anybody, anything, someone, somebody, something, everyone, everybody, everything.*

Each has its chemical properties.

- Plural indefinite pronoun subjects take plural verbs.

Plural: *several, few, both, many*

Both have similar electronegativity

- Some indefinite pronouns may be either singular or plural: with uncountable, use singular; with countable, use plural.

EITHER SINGULAR OR PLURAL: *some, any, none, all, most*

Some of the glass is on the floor.

Glass is uncountable; therefore, the sentence has a singular verb.

Some of the beakers are on the floor.

Beakers are countable; therefore, the sentence has a plural verb.

3. *Compound subjects joined by* **and** *are always plural.*

A pencil and an eraser make writing easier.

Sodium hydroxide and potassium hydroxide are alkaline solutions.

4. *With compound subjects joined by* **or/nor**, *the verb agrees with the subject nearer to it.*

Neither the hydroxides nor calcium carbonate is acidic solutions.

In this example, the singular verb **is** agrees with the nearer subject **calcium carbonate**.

Neither calcium carbonate nor the hydroxides are acidic solutions.

In the above example, the plural verb **are** agrees with the nearer subject **the hydroxides**.

5. ***Inverted Subjects*** *must agree with the verb.*

Unexpected colour appears because there was acid in the beaker. (There are red insects in the beaker).

6. ***Titles of single entities*** *(books, organizations, countries, etc.) are always* ***singular****.*

7. ***Plural form subjects***

-Plural form subjects with a singular meaning take a singular verb. (e.g. *news, measles, mumps, physics, etc.)*

Mumps is a contagious disease.

-Plural form subjects with singular or plural meaning take a singular or plural verb, depending on meaning. (e.g. *politics, economics,* etc.)

Mathematics is important in studying chemistry.

-In this example, *Mathematics* is a single topic; therefore, the sentence has a singular verb.

Statistics show that ….

-In this example, the word *Statistics* has a plural meaning; therefore, the sentence has a plural verb.

8. ***With subject and subjective complement of different number****, the verb always agrees with the subject.*

The studied *topic* is acids.

Acids are the studied topic.

9. **With *the number*** *of* ____, use a singular verb.

The number of molecules in 16 g of methane is 6.02 x 10^{23}**.**

With *a number of* ____, use a plural verb.

A number of scientists have investigated this subject.

Appendix 18

Handout 4.4.

Phrasal Verbs

1. Phrasal verbs

A phrasal verb is a phrase (such as *switch off*, *wake up* or *look down on*) that combines a *verb* with a *preposition* or *adverb* or both and that functions as a verb which meaning is different from the combined meanings of the individual words.

Phrasal verbs, though considered informal, are frequently used in academic writing. Many scholars advise students to avoid using phrasal verbs in academic writing because they may have unclear meaning. However, some phrasal verbs are accepted and widely used. For example; ***carry out*** (which is better than *do*) is a frequent one:

Scientists have **carried out** *experiments/tests/research on …*

The followings are examples of these phrasal verbs with their meaning:

Phrasal Verb: (in a sentence)	Meaning:
These results **accounts for** …	explain
These ideas are **based on** evidence	use facts to make a decision
Three experiments were **carried out** …	conduct; do
The study **consists of** three main parts.	be made of;
As it is **discussed by** Smith (2010), …	talk about
Most researchers **disapprove of** …	be against
The study intended to **find out** …	discover; illuminate
Researchers have **looked into** …	researched; investigated
Smith (2010) **pointed out** that …	explain; highlight
Each participant was **subjected to** …	cause or force to undergo
The final section is **devoted to** *a discussion of ...*	be used for
The essay **focuses on** *Smith's investigation and* **expands on/builds on** *previous work by ...*	emphasise do in addition to what have already been achieved
It is usually necessary to **refer to** other sources	use/mention/write about
Smith **puts forward** *the theory that ...*	suggest
All evidence **points towards** *this result*	show that something is true
Eventually, the size range was **narrowed down**.	reduce the number
To **sum up**, *the final results show…*	summarise/give brief summary
The other team **arrived at** *the same conclusions.*	reach

2. Students' Problem with Phrasal Verbs:

Phrasal verbs present difficulties for non-native speakers because their meaning is difficult or impossible to guess from the individual words that make them up *(this difficulty can easily be solved when you check dictionaries or other sources). However, the real problem that students usually confront with is choosing the correct particle (adverb / preposition); i.e., they -most of the time- use the wrong adverb/preposition with the verb.*

The examples below, derived from your papers, illustrate this problem:

Your verb	***Correct form***
These recommendations are **based** **at** *the results of extensive research.*	*based* ***on***
All the experiments were **subjected** **for** *strict controls and verifications …*	*subject* ***to***
The last addition of H_2O *to the solution* **resulted** **to**	*resulted* ***in***
Note that all the beakers are **made** **by** *glass.*	*made* ***of*** (the basic material)
Soap is **made** **by** *fat; therefore, …*	*made* ***from*** *(the original material have changed completely)*
The solution is **made** **by** *dissolving 4 g of salt in 500 ml of water (correct!)*	*made* ***by*** *(process of making something)*
McCleverty (2003) **points** **to/Ø** *that …*	*point* ***out***

In order to solve this problem, the students can use one-word verbs instead of phrasal verbs; however, not all phrasal verbs can be substituted or some phrasal verbs are preferred to one-word verbs (such as carry out). Thus, they have to check the meaning to be expressed and the correct particle (adverb / preposition) to be used in the phrasal verb.

Appendix 19

Lesson Plan (5)

Comprehensive Devices

Tutor: Ms. Kaouther BOUDJEMAA **Date:** May 2017
Learners: PhD Chemistry Students **Duration:** 3 Hours

Aim:

- To explain the rhetorical devices (Trimble, 1985) and show how they are useful in reading and writing.
- To provide them with useful strategies to benefit from reading articles in writing their articles.

Materials:
-Handouts:
*Examples of rhetorical devices

Steps	Procedure	Objectives
Introduction	You as science students are supposed to read and write scientific texts. During your studies, you need to read, understand and analyse texts to obtain required knowledge. In the same time, you will write (and you are writing) texts in order to express your thoughts and explain/convey your findings. Comprehension depends to a large extent on text characteristics and features (Brown, 1986) in addition to your understanding of the field (previous knowledge and experience) For that reason, you need some comprehension devices which are useful in reading and writing, and which simplifies both processes. A good example of these devices is the *rhetorical functions and techniques* (Trimble, 1985). They guide you through your reading and writing and let you understand the connection between ideas and the function of each piece of text which help you know what you are reading and what you have to write. These devices are as follows:	➢ To remind the students of the processes they are concerned with: reading and writing and explain the aim of the lesson.
Presentation	- ***Rhetorical Techniques*:** Are the elements that join and connect the sentences and words in a text and expresses the ideas. These techniques can be: natural orders and logical patterns. -*natural*: the order of ideas according to time and space (place): Link words can be used such as: *First, then, next, finally, …* in addition to the natural causality and result.	➢ To provide and explain rhetorical functions and techniques, and show how these devices are useful and important in both reading and writing.

	such as: *because, due to, since / as a result, consequently, …* -*logical*: caused by another factor (not natural) cause and result, order of importance, comparison and contrast, analogy, exemplification, illustration. *Comparative and superlative forms of adjectives/adverbs, similarities, for instance, …* - ***Rhetorical Functions*****:** Are about what a given unit -a piece of text- is trying to do. They make a strategy to present and organise information in a text. -**Definition**: an object can be defined in one sentence, one paragraph, … -**Description**: one paragraph (for example) can function as a description of a device/tool. It can be *physical* (of an instrument), *function* (how something works) or *process* (how something is done -steps). Notice: the same piece of text may have (or contain) more than one function: one principle and another supplementary. For instance, a paragraph can be a physical description of an apparatus and include a sentence which functions as a definition of one of the components of the apparatus. -**Classification**: classify an item into a larger group or find/track the group to which an item belongs. -**Instructions**: giving information about what to do and how to do it to fulfil a certain objective. For instance, it provides the steps of a process or a method. -**Visual-verbal relationship**: usually scientific texts make use of visuals (pictures, photos, graphic displays, tables, figures …). Within the text, these visual aids are explained or referred to and related to the whole content using a piece of text (verbal). This text functions as the relationship between the visuals and the text as a whole.	
***Read to write better**	**How to benefit from reading articles -in your field of study- in writing your own articles:** As you have mentioned earlier and noticed in your writings that one of your strategies is to imitate others writings or copy lines from already published papers. This strategy is not fully incorrect; you still can benefit from it. To do so, follow these steps: - After you finish reading an article (reading for scientific information), read it again looking for expressions that you can easily and correctly repeat or	➢ To provide them with a strategy that help them benefit from reading and facilitate their writing.

	reuse in your writing. - Create a bank (document) of such expressions (sentence templates) and make it easy to use whenever you need. - Combine this with another strategy of yours, which is "translating". Translate those expressions into Arabic (or French) to facilitate remembering and using them in the future. - Organise these expressions according to the section you extracted them from (Methods, Results, etc.). - Be careful of plagiarism; you may fall in the mistake of stealing others' ideas. - Do not copy complete sentences from others' articles. **HOW?** Remove words (usually nouns or noun phrases) that are related to the topic and replace them with your words (related to the topic you are discussing). Consider the following example: (Cargill & O'connor, 2009) As part of a long-term research effort aimed at ~~establishing a sustainable rain-fed farming system in the semi-arid and sub-humid regions of northwest China~~, this paper presents a detailed study on ~~the water use patterns and agronomic performance for some cropping systems with and without fallow crops in a semi-arid environment~~. The objectives of this study were to: (1) determine ~~the grain and aboveground biomass production and water-use efficiency of individual crops grown in the rotation~~; (2) analyze ~~the seasonal and inter-annual patterns of soil water storage and utilization as well as water stress for the four major rotation crops of winter wheat, corn, potato and millet~~; (3) determine ~~the grain and aboveground biomass production and water-use efficiency for different rotation systems~~ and evaluate ~~the capacities of the rotation systems with and without fallow crops to utilize soil water storage in conjunction with seasonal precipitation~~; (4) establish whether ~~the introduction of fallow crops into the wheat monoculture~~ significantly influences ~~the quantity of water stored in the soil that will be used by the subsequent wheat crop~~; and (5) discuss ~~the characteristics of soil conservation for different rotation systems~~. The template becomes: As part of a long-term research effort aimed at ……,	

	this paper presents …… . The objectives of this study were to: (1) determine …… ; (2) analyze …… ; (3) determine …… and evaluate …… ; (4) establish whether …… significantly influences …… ; and (5) discuss …… . *Note:* Use such templates only when they suit your description and writing and remember they can be modified.	

Feedback	* Students understood the provided rhetorical devices and appreciated the examples. * They appreciated the idea of creating templates from articles they read and use them while writing. It is similar to a way they used to but it was not correct or useful all the time. !

Appendix 20

Handout 5

Rhetorical Devices

1. Rhetorical Techniques:

The following table provides some of the common linking words that are used to express different types of information.

Sequence	Result	Reason	Example	Contrast	Comparison
-First / firstly, second / secondly, third / thirdly -Next, last, finally -In addition / Moreover / Furthermore -In conclusion / To summarise	-So -As a result -As a consequence -Therefore -Thus -Consequently -Hence -Due to	-For -Because -Since -As -Because of	-For example -For instance -Such as -Including -Namely	-However -Still / But / Yet -Although / Even though / Though -Despite / In spite of -In contrast (to) / in comparison -While / Whereas -On the other hand -On the contrary	- Similarly -Likewise -Like -Similar to -Same as -Compared to / with -Not only...but also

2. Rhetorical Functions:

2.1. Definition

- *A beaker is a glass container with a flat bottom that scientists use to hold liquids.*

- *An arachnid is an invertebrate animal having eight legs extending at equal intervals from a central body.*

2.2. Description

-*A beaker is generally a cylindrical container with a flat bottom and has a small spout (beak) to facilitate pouring. It is generally made of glass and can also be in metal or plastic.*

-*The blueprint machine is contained in a mental cabinet measuring 36 cm wide, 10cm tall, and 18cm deep.*

-*The topmost knob in blueprint machine controls the speed of the paper feed.*

- As the accompanying flowchart shows, a combined site investigation consists of these main steps:

1. Planning the program, with McDuf's scientists and engineers and the client's representatives

2. Reviewing existing data.

3. Completing a high-resolution geophysical survey of the site, followed by a preliminary analysis of the data.

4. Combining geophysical and engineering information into one final report for the client.

2.3. Classification

-All crystalline solids can be classified as members of one of fourteen crystal systems. The members of ways in which atomic arrangements can be repeated to form in solid is limited to fourteen by the geometrics of space division.

-The 61 species of birds on the island are grouping into: (1) loons, (2) grebes, (3) gulls and terns, (4) cranes, rails, and coots; and (5) ducks, geese, and swans.

2.4. Instruction

1- Prepare a very thin smear in the usual way, using a clean, grease-free slide.

2- At one end of the slide place one drop of nigrosin solution (2%).

3. Take another microscope slide, lay one end on the first slide at an angle of 30° touching the drop of nigrosin, and use it to push the nigrosin across the surface of the first slide. The smear will thus be covered with a thin, even, film a dye.

4- Allow the dye to dry and examine the preparation under the oil- immersion objective.

- Chemistry Laboratory Safety Rules:

- Do Not Pipette By Mouth - Ever.
- Read the Chemical Safety Information.
- Dress Appropriately.
- Identify the Safety Equipment.
- Do not Taste or Sniff Chemicals.
- Do not Casually Dispose of Chemicals down the Drain.
- Do not Play Mad Scientist.

2.5. Visual-verbal Relationship:

- *Table 1 shows …*

- *Figure 3 represents …*

- *It can be seen in Table 5 above that …*

Résumé

L'anglais sert de moyen de communication dans les domaines de la science, de la technologie, des affaires et de l'information universitaire. Dans les pays non anglophones, les devoirs des étudiants en sciences et des scientifiques sont doublés en raison de leur besoin d’utiliser l’anglais pour rechercher des informations dans leur domaine d'intérêt, c'est-à-dire qu’ils rédigent des articles scientifiques pour communiquer ses propres observations et découvertes. Ce besoin a conduit à l'émergence de plusieurs problèmes comme le cas des doctorants algériens en chimie à l’Université d’Annaba qui ont des difficultés à rédiger des articles scientifiques en anglais. Afin d'identifier ces difficultés, les articles scientifiques de 13 doctorants en chimie ont été analysés par une méthode d'analyse d'erreurs. Les difficultés détectées étaient principalement dues à leur faible niveau en anglais, à la manière peu pratique d'enseigner l'anglais dans les sciences et essentiellement à leur manque d'expérience dans la rédaction d'articles scientifiques en anglais. Il a été émis l’hypothèse que si ces étudiants recevaient une formation pratique en EST, ils surmonteraient ces difficultés et amélioreraient leurs performances dans la rédaction d'articles scientifiques. Une solution suggérée consiste à concevoir des cours sur l'anglais scientifique, principalement sur la rédaction d'articles scientifiques en anglais, ce qui devrait les aider à atteindre le niveau requis en anglais et à communiquer leurs découvertes correctement et de manière appropriée.

الملخص

تستخدم اللغة الإنجليزية كوسيلة للتواصل في مجالات العلوم والتكنولوجيا والأعمال والمعلومات الأكاديمية. في البلدان غير الناطقة باللغة الإنجليزية، تتضاعف واجبات طلاب العلوم والعلماء بسبب حاجتهم إلى استخدام اللغة الإنجليزية في البحث عن معلومات في مجال اهتمامهم وكتابة مقالات علمية لتوصيل ملاحظاتهم ونتائجهم. وقد أدت هذه الحاجة إلى ظهور عدة مشاكل كما هو الحال مع طلبة الدكتوراه الجزائريين في الكيمياء بجامعة عنابة الذين يجدون صعوبة في كتابة الأوراق العلمية باللغة الإنجليزية. من أجل تحديد هذه الصعوبات، تم تحليل المقالات العلمية لـ 13 طالب دكتوراه في الكيمياء من خلال طريقة تحليل الأخطاء. ترجع الصعوبات المكتشفة أساسًا إلى انخفاض مستواهم في اللغة الإنجليزية، والطريقة غير الملائمة لتعليم اللغة الإنجليزية في العلوم، وافتقارهم في الأساس إلى الخبرة في كتابة المقالات العلمية باللغة الإنجليزية. فرضية البحث هو أنه إذا تلقى هؤلاء الطلاب تدريبًا مناسبًا في الإنجليزية العلمية، فسوف يتغلبون على هذه الصعوبات ويعززون أدائهم في كتابة المقالات العلمية. الحل المقترح هنا هو تصميم دروس حول اللغة الإنجليزية العلمية، وخاصة كيفية كتابة المقالات العلمية باللغة الإنجليزية، والتي من المتوقع أن تساعدهم في تحقيق المستوى المطلوب في اللغة الإنجليزية وإيصال نتائجهم بشكل صحيح ومناسب.