CHAPTER-I

ENGLISH FOR SCIENCE AND TECHNOLOGY (EST)
THEORETICAL FRAMEWORK
CHAPTER-1

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Theoretical Framework

1.1 Origins of EST

1.1.1 The last two decades have marked a new era of enormous expansion in scientific and technical activities at a global scale. This expansion created a world mainly dominated by science and technology which soon generated a demand for an international language that might lead to viable communication in academic and professional activities of science and technology. For various reasons, most notably due to the emergence of the economic power of the United States in the post World War era, English became a potent means for learning science and technology. As a link language it has been playing since then an eminent role in communicating scientific findings, fulfilling professional needs and holding viable scientific discussion. These factors in the main motivated the students to take a greater interest in learning English not for pleasure or prestige but because English became the key to the international currencies of science and technology. Previously the reasons for learning English had not been well-defined. Students were learning English only to develop a general capacity for language use. It was cynically referred to as English for exam as if it aimed to cater to the
examination requirement only. The courses were literature oriented, hence less adaptable to the learners' specific needs. In addition, knowledge of English had been generally regarded as a sign of higher social status. Its practical utility had not been known to students. They had been learning English but very few had really been cognizant of its real benefits.

As English emerged as a predominant medium for learning books of science and technology, it created a new generation of learners who looked at English from utilitarian viewpoint and considered it as an important means to meet their identifying profile of needs. This led to the emergence of EST within the umbrella of ESP which is more oriented to the courses designed to meet particular needs of learners.

The emergence of this phenomenon may hence be attributed to the practice of using English as a predominant medium of scientific discussion and progress. The demand for mastery over the language used in scientific communication has thus increased with the rapid advancement of scientific knowledge. To respond to this demand and to explain interesting linguistic phenomena, Widdowson¹ (1975) has defined distinctive features of the

variety of English used in scientific contexts and termed it *Scientific English* or *English for Science and Technology* (*EST*).

1.1.2 Linguistics had earlier been concerned with mere description of the rules of English usage but now it has developed from defining the formal features of language usage to discovering the ways in which language is actively used in real life communication. The language which is used in real life communication varies considerably from one context to another and makes it possible to determine the features of specific situation and then to make these features the basis of learners' course. English needed by a particular group of learners could be identified by analyzing the linguistic characteristics of the learner's specialist area of work or study. Robinson (1980) has asserted the importance of needs analysis in English language teaching. Needs analysis, according to him, determines the variety of English that has to be needed or that has to be used in specific context. Robinson (1980) observes:

Tell me what you need English for and I will tell you English that you need.

This henceforth became the guiding principle for the origin of EST. The need to carry on varied academic activities in

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the field of science and technology has motivated the students of science to learn English to meet their specific needs. They felt that a certain degree of competence in English will ward off any hindrance and pave the way for considerable attainment in the pursuit of higher studies. Thus their awareness of the demand of English in science has increased. However the course materials that are available for English language teaching are literature oriented, hence less conducive to the development of the students’ language competence because, while teaching such materials teachers’ main thrust is usually on the teaching of literature rather than on language. Therefore ELT specialists have felt a need to design such specific course materials that are exclusively meant for EST students. Such a need for specification became an important factor for the origin of EST which is, in fact, an innovative idea for EST course planning and materials.

1.2 EST: A Definition

1.2.1 EST embarks on the specific aspect of language use and marks a departure from the view that learning of English must necessarily be accomplished through traditional teaching of literature or other culturally oriented language courses. It, thus, skirts culture bound materials and relies on the courses catering for the specific needs of learners.
It restricts learners to the acquisition of particular repertoire of formulae which can be applied directly to the solution of a particular range of problems. It fulfils their vocational requirements and makes them exclusively concerned with the utilitarian aspect of language acquisition which is perceived as successful performance in works in which English plays an auxiliary role. They want to gain proficiency in English in order to cope with their professional and occupational careers. Learning of English for them is not an end in itself, rather an essential means to obtain a clearly identified goal. EST becomes a prerequisite for the students of professional courses who are pursuing their careers in science but owing to language deficiency they are faced with the inability to understand textbooks, lectures and scientific discussion. English language programmes are, thus, made to train them for the language skills they really need to develop for their professional careers. A reasonable competence is equally important for the researchers who want to carry on their research activities and put their findings across the world. Besides, they need English to be operationally effective while communicating their scientific views with the specialists worldwide.

1.2.2 EST aims to develop the required competence in learners in order to enable them to communicate adequately
and effectively in target situations. The learners, hence, proceed by identifying the target situation which leads to needs analysis in EST. The needs analysis in EST incorporates a detailed analysis of learners' immediate demands for language learning and production of appropriate language materials which result in a well-defined syllabus and techniques for realizing the predetermined objectives. Munby's\(^3\) (1978) work on needs analysis is of paramount importance. His work, in broader sense, represents a socio-linguistic model for defining the content specific to the target communicative competence. Thus his model builds up a profile of students' needs and converts them into syllabus content. From the foregoing discussion it follows that the EST students study English not because they are interested in English language or English culture as such but they need English for study or work purposes. They specify as closely as possible what exactly it is that they have to do through the medium of English. Richterich\(^4\) (1973) also concentrates pointedly on the target course requirements. His definition of needs is worth quoting; such as:

> What seems crucial ultimately is that courses are designed with particular students and their

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immediate requirements in mind.

Here needs can refer to students’ study or job requirements, that is, what they have to be able to do at the end of their language course. This is a goal-oriented definition of needs which may be appropriately described as objective.

1.2.3 Needs analysis is, thus, a prerequisite for producing EST course materials. This is, in fact, a preliminary step in preparation for EST syllabus content because it identifies what the students of science urgently need to master in order to acquire communicative competence. This is undeniably true that once a profile of students’ needs has been built up the task for producing EST materials becomes easier to accomplish.

An EST course materials aim to develop in students who are entering higher education an ability to handle the kind of written English that they will be concerned with in pursuit of their academic careers. It also makes them aware of the way English is used in written communication and thereby helps them develop language competence that has to be used in scientific context.

Therefore an innovative EST syllabus relevant to the students’ immediate needs should be designed and taught to EST learners because they will learn effectively only through
materials that are inherently interesting. For EST learners English is instrumental, serving as an auxiliary role to the learning of their speciality. Through such course materials students will learn not only language but also how to apply this language to their own specific contexts.

1.3 Subdivisions of EST

EST, a prestigious sub-field of English for specific purposes (ESP) has now grown into an independent discipline for English language teaching. On the basis of Strevens's (1977) division of ESP, EST may also be divided into English used for educational purposes and for occupational purposes. Thus EST seems to belong to both the educational and the occupational uses of English. English for Educational Purposes (EEP) deals with the language needed by students in a study setting to cope with their own subject specialism such as to read books, journals, to follow lectures, to prepare laboratory reports and projects and to communicate their own views. They prefer the language courses to be subject specific rather than general. Such specification leads to the exclusion of other aspects of language use which do not serve the immediate needs of the students. English for Occupational Purposes (EOP) includes the acquisition of

English to get on far better with professional life such as English used by doctors to communicate with patients, scientists who want to publish their scientific achievements in reputed Journals or present their papers in international seminars and conferences and engineers who want to accomplish their tasks in English. EST further fits in with several other disciplines and consequently micro languages such as English used in Natural Sciences, Physical Sciences and Computer Science. In addition, unprecedented scientific and technological advances such as heart by-pass surgery, gene transplant, cloning and electronic mail have opened up new frontiers of knowledge. It has, in turn, led to the creation of new technological semantic fields, each with their specific lexical structures which are increasingly getting more specialized and complex. On account of such profound and dramatic improvement new terminologies are coined to name the scientific and technological equipments and to assign new terms in new ways to activities, processes or subjects resulting from research and investigation. These technical terminologies have a complex relationship which cannot be defined in isolation from their contexts. They are used in scientific and technical discourses to organize information and to change the nature of more common sense meaning.
1.4 Some Features of Scientific English

1.4.1 From the above discussion it follows that the quest for conceptual growth leads to new discoveries through which common words are charged with new meanings or are employed to represent newly established entities. This process gives a distinct identity to scientific discourse and makes learners ascertain its distinguishing features. Bradley (1968) has termed this process 'technicalizing process'. As a matter of fact he has evolved this device to interpret and reclassify the word in a different way from its normal practice in the natural spoken language. This device has made it interesting to note how the extension of meaning takes place in scientific compound words such as 'cold fusion'. This term may be clarified by considering a scientific event. An announcement was made about success in achieving "thermonuclear fusion". This occasion gives a glimpse of how a scientific discourse is developed, interpreted and reinterpreted. The scientists found the news astonishing about 'thermonuclear fusion' because the event did not fit in with scientific theories and models with which they were familiar. Hence, before accepting it as fact they wanted to know more about both the procedure and the result on which such a remarkable accomplishment was made and to test the evidence reported. Consequently researchers throughout the

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world started to duplicate "electro chemically induced nuclear fusion of deuterium" and dubbed it as 'cold fusion'.

It is also worth mentioning that words when they are compounded and reformulated in the scientific domain, their meanings undergo complete change. Such as 'cold' here qualifies neither the phenomenon fusion' nor the process which generates it. According to *Encyclopedia of Science and Technology*, during the cold fusion experiment temperature upto 1554 C is reached. The term 'fusion' in this context does not mean 'melt' Join, change of state or the like. It refers to definitive transformation of one chemical substance into another. This process involves the collision of particles brought about by chemical agents and heat energy and results in a chemical discharge with the release of radiation and heat energy.

The communicative potential of scientific discourse is thus located in the shared conceptual networks, methods, procedures and goals which underlie and generate scientific activities and which charge language structures with informative values.

The 'black body' is another compound, which gives different meanings if it is analyzed separately. According to *Oxford English Dictionary*, black means sky colour and

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body means physical parts but in scientific context it marks a departure from its commonly understood meaning and is charged with a new scientific meaning intelligible only to the specialists. Thus in science its meaning is not the same as it is understood in its everyday use. In scientific discourse it is a body which absorbs all the heat-rays and light rays which fall on it and reflects none. If it is heated it gives out the greatest possible amount of heat and light at that temperature. The problem of the black body was to find out how much energy on each wavelength is given out. The results found by experiment can be explained by the quantum theory.

Similarly "Cloud chamber" has different meaning if it is analyzed separately. Cloud generally means a mass of water and chamber means a large room but it has also a scientific meaning entirely different from its connotations in common parlance. 'Cloud Chamber' in scientific discourse is a container with gas (e.g. oxygen) and water-vapour in it. When an electrically charged particle (e.g. from radium) passes through the chamber it leaves a track of ions (electrified atoms or molecules). The gas is suddenly expanded. This makes water-vapour condense and form drops of water on the ions, thus making a white path which shows up the track of the particle.
Absolute Zero - 0°C on a centigrade thermometer, according to *Encyclopedia of Science*, is the temperature at which water freezes; but ice has some heat, e.g. ice is hotter than liquid air. At absolute zero there is no moment of the molecules and so no heat at all -: 273.13° centigrade: K degrees.

Hard water -: water containing salts of magnesium and calcium (as from a chalky soil); soap does not easily form lather in it.

Heavy water: consists of heavy hydrogen + oxygen

Annual ring: is a circular mark inside the trunk of a tree made by winter stopping and spring increasing the growth.

In addition to these scientific compound words, there are many other words such as gravity, tension, pressure, speed and velocity which do not have the same meanings for the laymen as they have for the scientists because they convey entirely different meanings within the ambit of their scientific studies.

As a matter of fact, the process of building up a technical vocabulary involves naming the phenomena and then making that name technical. This step aims to find the name for the phenomenon. Much of the technical taxonomizing
is a process of renaming in order to reclassify the vernacular meanings. Once they are reclassified, the vernacular becomes technical and specific to a field. Whether they are borrowed from the vernacular language or the language of another field. Once these words are set up as technical terms within a specific field, they acquire a meaning specific to that field. For example, the words cake, buttering, cavity and rubber have vernacular meanings that differ from the technicalized words in the following ways.

Cake: (most general meaning) a sweet, baked, bread-like food made with or without shortening and usually containing flour, sugar, baking powder or soda.

Specific meaning: a compact mass (to form into).

Buttering: (general meaning) to put butter on or in; spread or grease with butter.

Specific meaning: to give a substance butter-like consistency, like some plastics, or the act of covering a surface with a natural or other material.

Cavity: (general) any hollow place

Specific: a hollow in a piece of plastic due to a bad injection process

Rubber: (general) a highly elastic light cream or dark amber coloured solid substance polymerised by the drying
and coagulation of milky juice of rubber trees and plants

Specific: a material made by chemically treating and toughening this substance.

From the foregoing discussion it has now become evident that the scientist in order to evolve a scientific terminology either coins a new word best suited to his purpose or takes the word from ordinary native speech and gives it a special dress for scientific use. Such technicalizing process has been further discussed at length in chapter 5.1.

1.4.2 Another typical feature of scientific English is its nominalization which plays a key role in constituting technicality in scientific discourse. It frequently occurs in scientific texts thereby representing events and qualities of objects not as verbs, adjectives and adverbs but as nouns. For example

<table>
<thead>
<tr>
<th>noun</th>
<th>verb</th>
<th>adverb</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) The temperature</td>
<td>increases</td>
<td>sharply</td>
</tr>
</tbody>
</table>

In this sentence the subject is a noun and the verb a material process which may also be expressed as:

Adj N NA
A sharp increase in temperature

Where the verb ‘increase’ has been nominalized and the adverb ‘sharply’ has become an adjective in theme position
(II) Qualities can also be nominalized: for example, 'The thermoplastic is atactic' becomes The atacticity of the thermoplastic. 'An electron moves in an orbit' becomes 'the orbital motion of an electron'.

Thus nominalization is used to pack together a great number of events and states, leading to the formation of technical terms which stand for complex phenomena. It also allows the scientist for packing and compressing of complex information into a compact unit. For example the terms 'reaction injection moulding' (RIM) or 'glass reinforced plastics (GRP) moulding' describe, in the plastic domain, a great number of complex phenomena and interrelated events.

Nominalizations are also used to develop abstract scientific and technical concepts. As scientific knowledge advances and becomes more specialized, the complexity of the information requires the linguistic resource of nominal groups in order to put high level abstraction into words. For example, the title of a scientific research article often consists of a nominalized form plus one or more nominal groups of the type such as Classifier + Thing + Modifier, which represents a high level of abstraction. For instance, the nominalized form of the title "The Curvature of Material Surfaces in Isotropic Turbulence" compacts the

Nominalization, according to Halliday (1985)\textsuperscript{9} is an important resource for grouping meaning into theme and consequently, it is also a tool for organizing scientific texts. This may be illustrated by the following short text:

When the rubber is stretched, the polymer molecules uncoil or unwind due to rotation around the carbon-to-carbon bonds in the polymer chain. \textit{Such an uncoiling action} puts the bonds into an extended or unnatural state of high energy. This state causes the polymer to retract on being released, i.e. it returns to a lower energy state\textsuperscript{10}

In the above paragraph the scientist has used nominalized subject ‘such an uncoiling action’ which is

\begin{itemize}
  \item \textsuperscript{10} Beck, J.W. (1992). Polymer Molecules, Down to Earth, 5(14), 24
\end{itemize}
strongly associated with the theme that he wants to convey in the very beginning of the text. With the use of this grammatical device the scientist wants to add a new information to the preceding theme in the paragraph. So the predicate ‘puts the bonds into an extended or unnatural state’ is the new information that the scientist has presented by using nominalization which is in the subject position.

It is also worth noticing that the organization pattern in the above text is strongly associated with cause and effect relationships. Such as:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The rotation around carbon Polymer molecules</td>
<td>to carbon uncoil</td>
</tr>
<tr>
<td>2. The uncoiling action</td>
<td>bounds into unnatural state of high energy</td>
</tr>
<tr>
<td>3. This state</td>
<td>Polymer retracts</td>
</tr>
</tbody>
</table>

One thing more that needs to be mentioned here that topicalization has occurred in linear progression developed around a cause and effect chain, where the causes correspond to old information and the effects to new. This effect is mainly achieved by nominalization in theme position.
1.4.3 In writing on scientific or technical subjects, the writer often chooses scientific and technical (ST) syntactic structuring rather than common language structure (CL). CL versions are characterized by content verbs, active construction and the use of clauses, whereas ST Language versions stand out for the use of nominalization, participles, infinitives and a passive construction. In ST texts, some syntactic structures occur with greater frequency than they do in CL text. They include the use of passive, nominalization and participle constructions. Such syntactic structures are used frequently for a specific rhetorical function of scientific or technical subjects which determine the grammatical choice of the writers. However a writer must be sure whether or not the syntactic forms chosen are well suited to express a specific meaning. This process is called textualization. Textualization is the way a particular language realizes the concept and function of a particular type of discourse. It is concerned with the relationship between linguistic form and rhetorical function in the written language. In a more restricted sense it may be defined as the process of describing how grammatical structures match up with meaning.

It follows from the above discussion that scientific English is marked by technicalizing process, grammatical metaphor, ST lexical and syntactic structuring and the
complex relationship within technical compound words. The scientist in scientific text also prefers accuracy, highest degree of precision, exact and intellectual language and avoids, at all cost, the use of editorializing and non-logical arguments.

One more prominent feature of scientific English is its universality. That is to say the terminologies used in scientific text are universally acceptable because they are based on experiment, reason and rationale. In fact scientists shun all such perception and interpretation that have no empirical validity. They present only those findings which are proved by experiment. Scientists while communicating their findings are not, at all, governed by impulse and personal temperament. So the language they use gets rid of personal colouring and hence it becomes universal. In fact scientists use English to realize universal sets of concepts, methods and procedures which are independent of social and cultural influences. This, further, leads to the unity of scientific rhetoric which is accepted worldwide. The views of Widdowson\(^\text{11}\) (1977) in this regard are quite relevant. He regards scientific English as a powerful means to realize universal notions associated with scientific enquiry. Widdowson (1977) observes:

Scientific discourse is a universal mode of communicating or universal rhetoric which is realized by scientific text in different languages by the process of textualization.

Thus Widdowson (1977) believes that every scientist has to perform certain acts like the making of hypothesis, the calculating of results, writing of descriptions, instructions, reports, making of deduction etc. These are some of the basic rhetorical and methodological processes of scientific enquiry which are independent of the primary cultural systems associated with different societies.

It also seems worthwhile to discuss the distinction between scientific and literary English because it is likely to bring to notice some more inherent features of scientific English.

1.4.4 Distinction between Scientific and Literary English:

Heterogeneity of subject matter gives rise to the varied textual and discoursal patterns in writing system. Hence the scientific language is not a variety in the same way as the language of literature. In its nature and function the scientific language has proven markedly different from literary language. The scientific language is accurate, precise and experimental. It is an objective interpretation of facts and findings. It needs external and experimental evidence
to consolidate its validity. On the contrary, the literary language is subjective interpretation of life. It represents the artist’s inner self. It does not, at all, need external components and evidence to put forth the artists’ spontaneous expression.

According to Savory12 (1953) “the language of science is primarily concerned with efficiency and intelligibility not so much with beauty.” The language of science unlike literary language has, hence, realistic and logical implication. It is not governed by poetic or aesthetic impulse but whatever findings are explored or tested by valid experiments are put into exact magnitude. In contrast to this, the literary language is not assumed to put forth exact information because its prime aim is not to disseminate information as such but to stir readers’ aesthetic sense. Thus Milton’s *Paradise Lost* is read generally as literature and not for accurate religious information because Milton has artistically presented the theme of ‘man’s first disobedience’ and tactfully formulated ‘Satan’s rhetorical speeches. Similarly we don’t read Keats’s famous poem “*Ode to a Nightingale* for any information about that particular species of bird but we read it to explore symbolic implication associated with the bird. In fact, the bird has not been described in the poem in realistic terms but in imaginative terms. The description of imaginative bird

metaphorically draws our attention to trial and tribulation of life that the poet wants to overcome with the help of imagination such as:

Away! Away! For I will fly to thee
Not charioted by Bacchus and his pards,
But on the viewless wings of Poesy.\(^\text{13}\)

In the above stanza Keats has delineated an imaginative theme which needs no external evidence or experiment for its validity. He longs to withdraw himself from the stern realities of life on the viewless wings of poesy. To fly on viewless wings of poesy has symbolic significance. His ultimate resort for relief is poetic imagination. Poetry is his companion which will bring him beyond the worldly fever and fret. In addition to this, the ‘viewless wings of poesy’ is devoid of scientific and logical implication. In science, it will be wrong to say that poetry has invisible wings. The use of such words and interpretation is admissible only in poetic language because poetic language is imaginative language which may not be essentially supplemented by logic, reason and argument. In science the entire situation is other way round. Here Newton’s laws of Motion, Kepler’s Laws of Planetary and Galileo’s discoveries of hydrostatic balance are not, at all the result of poetic imagination but their

\(^{13}\) John Keats. Ode To Nightingale.
findings and discoveries are based on experiments, reason, evidence and logic. Literary artists take full liberty to distort and to recreate reality, because literature is not the element of truth or falsehood in which the assessment of its value is based. Whatever truth literature may yield its assessment is never based on whether it is true or false. On the contrary, scientific language tends to communicate the exact information because the validity of information is prerequisite in scientific composition. The aim of scientific language is not to arouse aesthetic pleasure and delight but to popularize new scientific findings. Thus the use of language in science is not the end in itself but it is just a potent means to the end.

1.4.5 The use of linguistic features is well maintained in scientific composition because any deviation from lexis and syntax in scientific English will, really, mar the easy grasp of the text, hence it is inadmissible. On the contrary, radical deviation from conventional norms tends to be the common core of poetic language. Grammatical and syntactic deviations which may be considered errors in scientific language become the expression of extraordinary worth in literature. Thus literature may be said to have autonomous linguistic structure. Leech\textsuperscript{14} (1965) has called such deviation

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14. Leech,G. (1965). This Bread I Break... Language and Interpretation (ed) Teaching Literature overseas
’foregrounding’ and claimed it to be the principle of aesthetic communication. Foregrounding is achieved therefore by the purposeful concentration of certain lexical or syntactic feature. In the following lines the foregrounding is achieved through unusual syntactic order.

(i) Slept Rip Winkle twenty years (Longfellow)
(ii) The door is strange to be unlocked (Dylan Thomas)
(iii) When will your round me going end (Hopkins)

In the normal expression these lines would probably read:

(i) Rip Van Winkle slept for twenty years. (Longfellow)
(ii) It is strange that the door is unlocked (Dylan Thomas)
(ii) When will you end your going round me? (Hopkins)

In the lines above the usual syntactic order is disturbed because the correspondence between subject and predicate is not regular. The literary artists have taken full liberty to violate the accepted rules of language and created their own rules which are not considered non-language within their own contexts. It is also worth noting that in scientific language no such liberty is permissible because in scientific composition findings are more important than artistic and metaphoric presentation. So to communicate well the findings
worldwide is the prime objective of the scientists. They do not seek to arouse emotion and present beauty or imaginative exploitation of language. They rather seek to make themselves understood.

Hunting rhymes are unnecessary and the association of ideas which contributes so much to the appeal of the language of poetry is a nuisance to the scientist.¹⁵

To sum up, the language used in poetry is metaphorical and it itself becomes the object of study. The accent, tonality, rhythm and the cadence are all essential to create poetic effect but they are all irrelevant in scientific language.

1.5 EST: An Appraisal

The most satisfactory efforts to define and describe the EST variety may be grouped into three main strands which in turn reflect the evolution of language analysis models over the last few decades. The first finds its origin in the works of Barber (1962).¹⁶ It applies register analysis scheme to sample of scientific texts and provides statistical data on mood, voice and length of sequences; occurrence of vocabulary; verb forms, verb-tenses, modal-verbs, clause-types and non-finite verbs.

The second has its roots in the works of Widdowson (1974)\textsuperscript{17}. He delineates the speech and rhetorical acts which are recurrent in scientific texts such as; "definition, classification, generalization, explanation, making hypothesis and drawing conclusions. The third has its source in the works of Trimble (1985)\textsuperscript{18}. He describes rationale or rhetorical considerations underlying paragraph formation and textual organization in EST texts. Trimble (1985) has further quantified and qualified grammatical patterns and speech and rhetorical acts used to express a large number of concepts and to describe a number of intellectual processes.

In dealing with scientific text Trimble (1985) has again focused his analysis on scientific rhetoric which he defines as follows:

\begin{quote}
Rhetoric is the process a writer uses to produce a desired piece of text. This process is basically one of the choosing and organizing information for a specific set of purposes and a specific set of readers. An EST text is concerned only with the presentation of facts.
\end{quote}


hypothesis and similar types of information. It is not concerned with the forms of written English that editorialise, express emotions or emotionally based arguments or are fictional or poetic in nature.\textsuperscript{19}

In other words, the rhetoric of scientific discourse is the way of using English to realize universal notions associated with scientific enquiry such as making hypothesis, calculating results, writing description, instruction, in which the information is organized. These notions constitute a specific format for EST writing. Trimble (1985) further classifies EST rhetoric that exists at several levels in scientific texts, such as:

**Level A. The objectives of the total discourse**

Example: 1. Detailing an experiment
   2. Making a recommendation
   3. Presenting new hypothesis or theory
   4. Presenting other types of EST information

**Level B: The general rhetorical functions that develop the objectives of level A**

Example: 1. Stating purpose

\textsuperscript{19} Ibid, p. 10.
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.

**Level C:** The specific rhetorical functions that develop the general rhetorical functions of level B.

Examples:
1. Description: Physical, function and process
2. Definition
3. Classification
4. Instruction
5. Visual-verbal relationship

**Level D:** The rhetorical techniques that provide relationships within and between the rhetorical units of level C.

Examples:
1. Orders: (a) Time order (b) Space order (c) Causality and result
2. Patterns: (a) Causality and result (b) Order of importance (c) Comparison and contrast (d) Analogy (e) Exemplification (f) Illustration
The aforesaid rhetorical process chart gives an idea of the kinds of information each level contains and exhibits how various units of information are related to one another. Level A gives the purpose of the total discourse which is usually found in the introductory section of a technical article. Level B consists of those major pieces of text, which, when added together make up the complete discourse. This level is usually marked in scientific and technical writing by section, headings or sub-headings. In addition, the detailing of an experiment in a scientific article as referred to at level A, also includes a description of the apparatus being used and a description of how that apparatus works. The writer then in developing his ideas is required to choose one or more of the general rhetorical functions at level B in order to obtain the objective of Level A. In this case, the required function is presenting apparatus used in an experiment such as description and operation.

The rhetorical process is best seen operating at levels C and D. Level C is made up of the specific rhetorical functions that are found most commonly in written EST discourse such as description, definition, classification, instructions and visual-verbal relationships between a visual aid and its accompanying text. Most commonly the discourse at this level is presented in groups of closely
related paragraphs or in single paragraph. Information on the description and operation of apparatus can only be presented to the reader through the specific rhetorical function of description at Level C. Similarly, the use of rhetorical function of description requires the writer to choose one or more of the rhetorical techniques listed in level D. By its very nature, discourse concerned with the physical description of an object demands the use of the rhetorical technique of space order. The writer also chooses the rhetorical technique of process time and with it, the relational pattern of causality and result. In sum, the function chosen at one level almost inevitably determines those to be chosen at the next level.