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Reading of The English of Science and Technology : An Overview of the Literature

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For the last year and a half I have attempted to teach science students how to read English. These students are of varied linguistic and educational backgrounds with varying degrees of reading abilities. I have sometimes experienced a certain amount of frustration or uncertainty when trying to present material which could be of future use to my students in their fields. It seems to me that if they are not exposed to certain types of readings containing the vocabulary, the structures, and the concepts they will need to know, then the reading curriculum has not met their needs. I have then decided that the best way to be of more help to my students would be to do some research in the field. Perhaps, if I were more acquainted with this specialized field I would be able to furnish my students with reading material that would be a great deal more related to their interests and reading ability.

EST is a part of English for Special Purposes (ESP). And what is ESP? Because ESP has become a fashion or bandwagon among some teachers and educational circles, the label ESP is now used in widely disparate circumstances and is difficult to define. Almost the only universal characteristic of all ESP courses is that they do not teach "general English"--a course of a conventional, general-educational kind.

ESP courses differ from each other fairly obviously along a number of dimensions, e.g. : (i) area of specialization , (ii) restriction of language skill ; (iii) specificity of language ; (iv) pedagogical methods.

According to Strevens (1977) ESP is a young but rapidly expanding branch of TEFL. Excellent results in ESP can be achieved if maximum sophistication of language teaching and syllabus design can be obtained. Attracting teachers of high skill and intelligence would also enhance the future development of ESP.

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In a course on English for Science and Technology (EST) which Dr. Peter Strevens taught at the Regional English Language Centre (RELC in Singapore) in October 1971, he developed a useful classification system for the ways people in different fields of science use English. His definitions were as follows :

Scientific English : uses the full range of general and scientific concepts, philosophical as well as methodological ; it uses the stock of international scientific terminology based on Greek and Latin roots, the terms of particular branches of science and other concepts ; it assumes familiarity with the symbols and visual conventions of mathematics. However, except for the field of mathematics itself, it uses less quantification than occurs in Technical English. A second definition of Scientific English by Widdowson (1974) which brings out peculiar characteristics of this area is that Scientific English tends to remove the elements of addresser/addressee from a communicative situation, making the message that is being conveyed sound "detached" and "objective." Both the impersonal agent-less passives, and passive-like statives are of common occurence in scientific writing. The same is true with the use of the pronoun "we" to refer to both the addresser and the addressee.

Technical English : uses little of the language of general, philosophical or even methodological concepts. The special terminology used relates chiefly to concrete objects and practical processes rather than to abstractions. Quantification is mainly a matter of stating measurements rather than the symbolization of mathematical relationships. There is a good deal of nonscientific or "common core" English interspersed in technical texts.

Now that certain definitions have been given, the reader has a clearer idea of the field of English for Special Purposes and especially of English for Science and Technology, the main focus of this paper.

General Introduction

Latorre (1978) believes that the growing interest in teaching of English at the university and college levels in developing countries is due to the fact that the majority of the specialized textbooks and periodicals are in English, and also due to a considerable number of scholarships for future training in countries where English is either the native language, the second language, or the most used medium of communication.

It is clear that the vast amount of technical information produced by the United States, in particular, and also by Great Britain has made English the lingua franca of the international scientific community.

The specific area within the field of English for Science and Technology this article will attempt to explore is *Reading*. But, before one can explore reading in EST, one must know what the current thoughts are on the reading process in general.

For efficient reading one must eyespan key words and multiword groups. 'Efficient reading does not result from precise perception and identification of all elements, but from skill in selecting the fewest most productive cues necessary to produce guesses which are right the first time.' (Goodman, 1972). The reader must be able to recognize contextual clues, structural clues and orthographic clues such as punctuation, indentation and capitalization.

Without mastery of sentence level comprehension, understanding on the discourse level is necessarily frustrated. Comprehension on the discourse level involves extracting the core idea of a paragraph (or a series of paragraphs). Then the students must tie together a series of core ideas for full understanding of a lengthier reading selection.

Research in EST

The principal work in the nature of scientific rhetoric has been done by Selinker, Lackstrom, Trimble, Trimble and Vroman. Their notion is that there are certain rhetorical principles that manifest themselves to a high degree in scientific prose which set it apart from general English discourse.

A major reading difficulty among foreign readers learning to read English deals with misconceptions of paragraph construction. Selinker and his colleagues (1976) believe that perhaps it is better to teach the idea of a "conceptual paragraph" which may consist of one or more paragraphs which have one core generalization. Selinker's group contends that the reader must extract and then reorder the information in order to understand the relationship between juxtaposed pieces of information. They believe that important parts of the supporting information are often implicitly rather than explicitly stated and that this implicit information is frequently rhetorical in nature. Selinker says that if the non-native reader does not understand the meaning of this rhetorical information nor see the various ways in which it may relate to core generalizations, then he will not be able to gain access to the total informational content of the discourse.

A further point Selinker and his group make is that teaching the idea of a "conceptual" paragraph is not enough, because a great amount of implicit information is burried within even this broader view of the nature of the paragraph. Teaching the use of rhetoric in EST can give the student a strategy to extract all the information from a passage. Without such strategies, they see the student's level of reading comprehension as stagnating on a "fossilized plateau," using only explicit information.

In discussing the nature of rhetoric in EST, the question arises as to whether the use of rhetoric is really any different from general English. All rhetorical devices found in EST are found in general English. But proponents of EST point

to the relatively high occurrence in scientific English of particular rhetorical functions and techniques, and many will say that the whole is greater than the sum of its parts : that the rhetorical organization of technical rhetoric not only serves the special needs of science, but in fact reflects the nature of scientific concepts.

In their article "Rhetorical Function-Shifts in EST Discourse" Selinker et al, have tried to study what appears to be a serious learning problem for advanced learners attempting to read their subject matter in English. This problem is their inability to understand the total meaning of a written portion of EST discourse even when he or she may be able to understand all of the individual words in each sentence and/or all of the sentences in a particular paragraph.

The authors describe two methods of EST paragraph development : rhetorical process development and rhetorical function-shift development. Rhetorical process development is a type of paragraph development in which there is clearly stated (or clearly implied) a core generalization and supporting (developmental) information. Selinker et al hypothesize that this type of paragraph development acts within the organizational and content constraints on the technical writing set up by the rhetorical process hierarchy. This is especially true in the type of EST writing called "Detailing an Experiment"-the type of EST writing upon which the authors base most of their conclusions.

Although Selinker et al believe that "rhetorical process development" characterizes, in general, a large number of EST paragraphs, not all paragraphs are of this type. A second type of EST paragraph development they have discovered is the "rhetorical function-shift development." This type of paragraph lacks clearly stated core ideas.

There are other researchers who believe other factors cause reading difficulties for foreign students in EST. Kaplan (1972) says that logic, the basis of rhetoric in the popular sense, is evolved out of culture. It is not universal. That means then that rhetoric is not universal either, but varies from culture to culture.

Therefore, when reading, non-native speakers have problems understanding the "logical" organization of thought in English paragraphs and struggle with the high value placed on the ability to reason and to deduce in reading comprehension.

For many years the teachers of specialized English courses for non-native speakers have had the belief that a knowledge of technical terms acquired through a glossary, for example, was sufficient when learning to read specialized materials, such as scientific texts. However, experience has shown that even when the technical words are known, the non-native speaker becomes very frustrated with the painful and slow process of reading in a foreign language. He tries to find native language summaries of the English texts, finds native language books covering roughly the

same material, or does·not read the material at all, concentrating only on taking lecture notes. Such an approach tends to produce a passive learning attitude in these students rather than a lively, exploring approach which is so essential if they are to develop enough competence in English to read their subject matter freely. Other research has shown that the problem of reading scientific English extends beyond technical vocabulary. Selinker and Trimble (1974), for example, demonstrated that the use of articles and the use of verb tenses in specialized texts reflected rhetorical and organizational decisions made by the author. That is to say, the choice of definite or indefinite articles might reflect the amount of generalization that the author wishes to presuppose, and a shift from past tense to present perfect tense in discussing past research might indicate that the research in question is more immediately relevant to the experiment at hand. The non-native reader is very often not aware of these devices. Selinker, Todd Trimble and Trimble (1976) have also shown how definition and classification schemes which are non-explicit in the text can cause problems for non-natives. "Causing problems" for the non-native often means simply lack of information or awareness of the function of the rhetorical devices.

Cohen et al (1978) did a series of studies which were an outgrowth of a graduate seminar Larry Selinker conducted at the Hebrew University of Jerusalem, 1975-76. The three areas of most difficulty were rankshifted structures, non-technical and technical vocabulary, and connectors as adhesive elements.

According to Sinclair (1972), a "rankshifted structure" is a "stretch of language which looks like a clause, but behaves like a word...." Based on students' responses concerning these structures it was found that across texts and across specialized fields, long groups of words performing a single grammatical function were difficult for non-native readers to perceive as such.

The studies of Cohen clearly pointed out that mastering vocabulary is not a sufficient condition for the successful reading of specialized material. It was, in fact, the non-technical terms which created more of a problem. This seems to point out that useful work can be done in teaching students different categories of non-technical vocabulary.

A certain amount of research has been done on scientific vocabulary. Scientific vocabulary is often thought to be the stumbling block in EST-probably the most misunderstood aspect of the disciplines because of the fear it endangers. Teachers complain they could never teach EST because they do not know the vocabulary. They might realize that they are reacting like their general English students who also believe that all they need to know is lists of vocabulary words.

It is not the duty of the EST teacher to teach Science, and under normal circumstances that excludes highly technical vocabulary from the classroom. But, what

is the nature of vocabulary selection for EST? The focus is a sub-technical vocabulary which is defined as... "context indegendent words which occur with high frequency across disciplines" (Cowan, 1974).

An additional aspect of vocabulary is the presence of a great number of Greek and Latin roots and affixes such as "aqua-, zoo-, pre-, post-, -ics", etc.

Cohen's studies revealed that learners did not know the cognitive markers of cohesion, not even the basic ones like 'however' and 'thus'. It was also discovered that the non-natives in one of the studies could not organize the material that they had read when that organization stretched across different paragraphs, although cross-paragraph cohesive markers were provided in the text.

There is also more evidence in which it appears that the non-native subjects read more locally than the natives; in other words, they had more trouble linking up parts of sentences, linking sentences with other sentences, and linking paragraph with other paragraphs.

In a study he carried out among medical students at Tehran University, Cowan (1976) agreed with Eskey's (1971) findings concerning the two biggest linguistic impediments for the "decoding process." These are :

1. Vocabulary problem
2. Structural problem

He claims that more and better EFL materials can be devised if, for example, focus is placed on "sub-technical vocabulary." He believes that if high frequency structural patterns in scientific English are carefully studied and isolated, then teaching points could be derived. Students would be given practice in recognizing and decoding the more complex structures characteristic of scientific prose. Secondly, a complete stylistic analysis would make the sequencing of materials less arbitrary.

In his research, Widdowson (1974) points out that in scientific uses of language the tendency is to avoid the first and second persons and the predominant person is the third one. Although the first person "I" is commonly avoided in scientific writing, the pronoun "we", does occur with some frequency. It is commonly used to refer to both addresser and addressee, as in expressions of the form: "We have seen that..., "We now observe that"...

In his article Widdowson mentions the creation of new terms in scientific writing. In science new terms are often compound nouns. These compound nouns can cause considerable difficulty to learners because the grammatical relations underlying them can be quite different. A "copper electrode", for example, is "an electrode which is made of copper", and a "combustion chamber" is a "chamber which is used for combustion." The question that arises is: if such compound terms can cause difficulty, why are they used? Why not say "an electrode which is made of copper,"

or, "a chamber which is used for combustion" and so on? The answer is that, as with the active and passive sentences discussed earlier, the compound term and the phrase with the relative clause, although grammatically equivalent, do not have the same communicative value. The use of the relative clause is to make an initial identification of a particular object or event in terms of certain attributes, so as to distinguish it from others in the same class. The compound term is used to refer to something which is already conceived of as a simple entity, as an item in a class of its own.

According to Widdowson (1974), what has to be taught is an awareness of how these forms were used in the performance of such acts of communication as definitions, generalizations, descriptions, reports, and so on. In short, what has to be taught is how the writer uses language to impose a rational order on the facts which he discovers, hidden under an everyday view of the world.

At this point I wish to present a summary of the findings in the research given here. On the next page is a chart with a list of the researchers mentioned in the paper and the areas that they have found to be *difficult* for foreign EST students.

Findings

1. Cohen Andrew et al	1. rankshifted structures, non-technical and technical vocabulary and connectors as cohesive elements 2. interpretation of modals, the significance of punctuation of the lack of it and various problems related to long complex sentences
2. Cowan, J.R.	1. Sub-technical vocabulary 2. Structural patterns present in EST
3. Kaplan	1. logic, the basis of rhetoric
4. a. Selinker, Todd-Trimble and Trimble	1. definitions and classification schemes which are non-explicit in the text
b. Selinker, Trimble, Trimble, and Vroman	1. the idea of a "physical" paragraph VS. a "conceptual" paragrahp
c. Selinker, et al	1. the rhetoric in EST
d. Selinker, Trimble and Vroman	1. tense usage (as a rhetorical and organizational decision made by author) 2. modals 3. verb complementation 4. nominalization 5. noun compounding
e. Selinker and Trimble	1. use of articles/as a reflection of rhetorical and organizational decision made by the author
5. Widdowson, H.G.W.	1. Compound nouns or nominal phrases 2. passive forms/use of third person

The overlapping areas in which different research findings coincided were:

a. tense usage/choice of tense
b. vocabulary, sub-technical (noun-technical, technical)
c. connectors as cohesive elements
   structure words (although, for, provided)
d. noun compounding/compound nouns
e. definitions
f. differences between students L1 and L2

The pedagogical implications which can be extracted from this research seem to be related to the designing of programs or courses to address in the areas of student difficulty. Areas a-f above may be used as the focal points for the teaching of EST.

Conculsion

After analyzing the information I was able to gather, concerning Reading in EST, I believe that a good portion of it does give a good insight to the field. Several researchers agree on certain areas of student difficulty such as sub-technical vocabulary and tense usage or choice of tense. These two seem to surface as the most problematic. The rhetorical and organizational uses of the language were also stressed especially by Selinker and his colleagues who have done a great deal of the, research in EST. Intuitively, I feel that these areas in which more future research should be done without, of course, ignoring other areas in which international EST students seem to be weak. One of these areas which I feel should not be ignored is the notion of the 'physical' vs. the 'conceptual' paragraph.

Because I am interested in the pedagogical aspect or application of findings of research in Reading in EST I wish to include a few teaching suggestions which may prove helpful. These are :

1. Giving traditionally-trained teachers a general background in the rhetoric and structures of scientific English and a sufficient preparation in linguistics to enable them to act, to react, create, and innovate.

2. Proper development of programs to meet the specific needs of students-be they practical or theoretical.

3. Development of a good core of EST materials-the field is still relatively young and does not have the acquired experience that comes with time.

4. Extract sub-technical vocabulary from the assigned materials in an EST class or program and pre teach them.

5. Greek and Latin roots and affixes such as "aqua-", "zoo-", "pre-", etc., should be taught since these are very valuable in decoding.

6. EST teachers can help their students by pointing out the differences in tense choice prior to reading instruction so that the student can better understand his scientific material.

7. Excercises using connectors and compound nouns should be interspersed within the regular reading instruction in the EST classroom. By consulting journal articles on the latest information is EST, the teacher can obtain ideas for types of exercise to develop.

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