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ABSTRACT

Undergraduate students of English for Science and Technology (EST) are confronted, in their English textbooks, with a variety of rhetorical forms intended to convey a variety of information, including specialized rhetorics of definition, classification, and argumentation. The rhetorical form of EST argumentation is the organization of written presentations in EST textbooks intending to support or invalidate hypotheses and theories through presentation of experimental evidence. The ability to understand literal meanings of sentences contained in these arguments is insufficient for the full comprehension of the arguments because of their frequently elliptical character. In addition, the skills needed to interpret elliptical EST arguments are very close to those required to interpret ordinary conversational English, and teaching reading comprehension of EST arguments amounts to teaching communicative competence in EST. (MSE)

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THE READING COMPREHENSION OF ELLIPTICAL ARGUMENTS IN EST* TEXTBOOKS

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Undergraduate students students studying in EST are confronted in their introductory science textbooks with a variety of rhetorical forms intending to convey a similar variety of information. There are, among others, specialized rhetorics of definition, classification and argumentation. I wish to discuss today in some detail the rhetorical form which I will call EST argumentation or the EST argument. By EST argumentation I mean the organization of written presentations in EST textbooks which intend to support or invalidate hypotheses and theories and which do so through the presentation of experimental evidence. I will attempt to show that an ability to understand the literal meanings of the sentences contained in such arguments is insufficient for the full comprehension of the arguments because of their frequently elliptical character. I will argue that the skills which must be applied to the interpretation of elliptical EST arguments are almost precisely those required for the interpretation of ordinary conver-

*EST = English for Science and Technology sational English. Finally, I will suggest that, given the nature of the reading comprehension task for EST argumentation, teaching the reading comprehension of EST arguments amounts to teaching communicative competence in EST.

Let's consider first of all an example of a non-elliptical argument in EST (Fig.1). It contains rhetorically five organizational parts. First, the statement of the problem (ln.1 -5). Next the hypothesis or proposed solution (ln.6-7). Then follows a statement of the consequences of the hypothesis (ln.7-10). The statement of the consequences serves logically to relate the eventual test and results to a validity judgement about the hypothesis. Next follows the description of the test and statement of the results (ln.11-16). Finally, the non-elliptical argument reaches a conclusion concerning the validity of the hypothesis (ln. 18-21).

The non-elliptical EST argument is really an informal, abbreviated version of an experimental report. The presentation follows an outline very similar to the explicit rhetorical organization of a formal experimental report (Fig. 2). It is interesting to note in this regard that if one compares EST textbook arguments involving experiments, the predominant reading of undergraduates, with formal experimental reports, read predominantly by graduate students, one finds that graduate students read EST which is explicit in rhetorical form and which presupposed a good deal of content while undergraduates read mostly EST explicit in content but lacking explicitness in rhetorical organization. This lack of rhetorical explicitness is of some consequence to the undergraduate student in EST since whether he is being presented with definitions, conceptual generalizations or theoretical EST arguments, he must retain different sorts of information. EST arguments in particular require that the student take note not only of the conclusion, but of the means by which the conclusion was arrived at. It would not be generally sufficient, for example, having read the account of Torricelli's experiment to note only that air exerts pressure. The reader would also normally be expected to retain the reasons why Torricelli reached his conclusion.

Questions of rhetorical explicitness aside, presentations that undergraduate students in EST read are rarely as direct and straightforward as the discussion of Torricelli's experiment in Fig. 1. In most cases, severe ellipsis has taken place in the presentation of the argument. The reader must, therefore, not only supply the rhetorical organization, he must also fill in gaps in the presentation. Consider the presentation of the Michelson-Morley experiment in Fig. 3. The presentation begins with the statement of the problem. It continues not with a statement of the hypothesis, but with a description of the consequences of an unstated hypothesis, namely that the earth moves through ether. The description of the evidence and the results follows and the argument ends. The conclusion, namely, that the earth does not move through ether is left unstated and must be inferred by the reader.

What we learn from the EST argument exemplified in the description of the Michelson-Morley experiment is that the task of reading in EST involves considerably more than extracting the meanings from the sentences found in the passage.since more information is being conveyed than is being explicitly stated: First, that the issue at which the argument is being directed is the question of whether or not the earth moves through ether (unstated hypothesis). Second, that the evidence shows that the earth does not move through ether (unstated conclusion). And third, that the presentation as a whole constitutes an invalidation of the ether hypothesis (unstated point of the passage).

The pedagogical conclusion to be reached from the EST argument in Fig. 3, is that the teaching of reading comprehension and especially "critical reading" as it is sometimes called[1], reading which extracts more than the literal meanings from sentences and passages, has to involve more than the teaching of vocabulary and of sentence structure. In an effort to make precise what else needs to be taught, I will first try to relate the observations I have made concerning EST arguments to work that has been done in relation to the conversational language, show that the principles are applicable also to EST and finally offer some pedagogical suggestions for teaching the reading comprehension of EST arguments.

CONVERSATIONAL POSTULATES

Grice[2] and Gordon and Lakoff[3] have discussed the role of what they have called "conversational postulates" in linguistic communication. The concept of the conversational postulate derives from the observation that speakers often use one sentence to convey the meaning of another. Thus one may order or suggest to another that he close a window or door by uttering the sentence, "It's cold in here." In the example, the utterance of a statement carries the speech act potential of a command or suggestion. Gordon and Lakoff attempt to account for such observations by formulating conversational postulates which will predict the circumstances under which certain kinds of utterances will have both literal meanings (a statement about room temperature) and conveyed meanings (a command or a request). The postulates, therefore, can be expressed as conditions under which certain kinds of speech acts can appropriately be performed. These conditions are grouped under the general categories of sincerity, reasonableness and the cooperative principle. The sincerity conditions involve such requirements as if you request someone to do something, then you must want him to do it. The reasonableness conditions are such requirements as assuming the hearer can perform the request and is willing to perform it.

Gordon and Lakoff also discuss Grice's Cooperative Principle. The notion behind the cooperative principle is that in contexts in which the speaker wishes to inform his audience, he will provide them with all the information that he assumes to be relevant to their informational needs. Gordon and Lakoff (p. 6) provide an example of uncooperativeness in this respect:

> ...Suppose that at a party all the guests leave early and this upsets the host. If someone asked you what had happened, it would be uncooperative to reply, "Someone left early," though strictly speaking it would be true.

Now consider a somewhat different example, again from Gordon and Lakoff (p. 7). Suppose you meet a friend on the street and say to him,"Your wife is faithful." He would most certainly express surprise or anger, the reason being that you had violated the second half of the cooperative principle which is to avoid saying what the audience already knows or takes for granted. The cooperative principle as a conversational postulate predicts that speakers will say no more nor less than what they believe their listeners will require.

<u>INFERENCE IN THE INTERPRETATION OF SPEECH</u>

John Searle[4] has argued convincingly that one can get along theoretically without a lot of *ad hoc* conversational postulates in describing conveyed,but not expressed, meanings. Language users, he insists, don't have a lot of postulates floating around in their heads. What they do possess, he argues, is a certain amount of shared knowledge between the speaker and the hearer, a theory of speech acts by which they know what is necessary to a valid request, proposal, promise, etc., and an agreement on the cooperative principle whereby it is understood that a speaker has a point to uttering sentences, and that he will say no more nor less than what is necessary to get that point across. In addition it is assumed that the hearer can make logical inferences, and so the speaker will often not state that which he assumes the hearer can infer.

Searle illustrates with an example: You say to someone, "Let's go to the movies.", which constitutes a proposal. He replies, "I have to study for exams.", which constitutes a rejection. The question Searle raises is why does that statement constitute a rejection in contrast to "I have to eat popcorn." or "I have to tie my shoe.", which would not be rejections of the proposal. The statement, "I have to study for exams." constitutes a rejection, he argues by virtue of a chain of inferences constructed by the hearer:

1) The hearer assumes the speaker is cooperating in the conversation, therefore what speaker says must be relevant to the proposal. Since the literal response would not be relevant, the speaker must be accepting or rejecting the proposal with the statement he uttered.

2) The hearer understands that the preparatory condition for the acceptance of a proposal is the ability to accept it (the hearer's understanding of speech act theory) and concludes that the speaker must be alluding to his ability to accept the proposal.

3) The hearer has the conventional knowledge that going to the movies and studying for exams are both activities of relatively long duration (contrast eating popcorn and tying shoes).

4) The hearer applies logic to infer that since it would be impossible to both go to the movies and study for exams in the same time period, the speaker must be alluding to his inability to go to the movies and is therefore rejecting the proposal.

The hearer thus uses the cooperative principle, his knowledge of the conditions on speech acts, conventional knowledge and logic to arrive at the correct interpretation of the speaker's response as a rejection of his proposal.

The Searle example is reminiscent of the elliptical argument illustrated with the Michelson-Morley example in that in both cases more content is intended than stated. The similarity in the cases suggests that EST readers and speakers of conversational language must apply the same kinds of strategies and knowledge. The EST reader must share with the writer some knowledge (note the reference in Fig. 3 to "interference fringes" discussed in other chapters). Where all language users must have a theory of speech acts, EST readers must know the rhetorical form of an EST argument. The EST reader must also accept the cooperative principle that the EST writer has a point to ma..e and be willing to apply logical inference to seek the point out.

Applying these strategies to the Michelson-Morley example, the critical EST reader will note that the author has not supplied him with an explicit hypothesis. This observation depends on his knowledge of the rhetoric of EST. The reader will say to himself,"There must be some point the author is trying to make." This step entails the acceptance of the cooperative principle. Finally the reader will deduce from the statement of consequences the intended hypothesis of the author: that the earth moves through ether.

PEDAGOGY

Having outlined what the EST reader must know and be able to do, we turn to what he must be taught. The first step for the beginning student in EST is t learn the scientific method and its application. Although various versions of the method are available, one which I have found useful is found in Figure 4:

1. Find a problem
2. Hypothesize a solution
3. Deduce the consequences of the hypothesis
4. Test the hypothesis against its logical consequences
5. Observe the results
6. Reach a conclusion concerning the validity of the hypothesis

One advantage of the scientific method as outlined in Fig. 4 is that it coincides nicely with the outline of the formal scientific report in Fig. 5:

I. INTRODUCTION

II. THE EXPERIMENT

A. APPARATUS

B. PROCEDURES

III. RESULTS

IV. DISCUSSION

The Introduction contains the statement of the problem, the hypothesis and the consequences of the hypothesis. The description of the experiment is the test of the hypothesis against its consequences. Following the statement of the observed results, the Discussion section contains the conclusions concerning the validity of the hypothesis and any practical or theoretical consequences that follow from its validity. The teacher may wish to have at his disposal a few problems that can be resolved by experimentation in the classroom or laboratory. The students individually or in groups can follow the scientific method to solve the problems and write up the results in abbreviated experimental report form. An example of one such exercise is included as Figure 6 in the handout.

When the students demonstrate an understanding of the scientific method and an acceptable proficiency in writing up brief reports, they are provided with a series of tasks whose objective is to identify the rhetorical parts of an informal prose description. Figure 7 is a matching task to be accomplished after having read an account of Dalton's validation of the atomic theory. Figure 8 illustrates another sort of task, one in which parts of the brief experimental report are given and others are left for the student to extract from his reading. The tasks are graded in difficulty and eventually involve the student's filling in content conveyed but not explicitly stated, as in Figure 9 where the conclusion must be reached by inference. In completing the task acceptably, the student must state themselves the unstated conclusion that centrifugal force plays no role in the theory of subatomic particles.

Through activities like these and others the students are taught to perform and interpret EST arguments very much like they will have to perform and interpret EST arguments as student scholars: preparing short experimental reports and taking notes on their textbook reading. Teaching the reading comprehension of EST is, in effect, teaching communicative competence in EST.

COMMUNICATIVE COMPETENCE

Teachers of foreign and second languages have become concerned in recent years with the teaching of what has come to be known as "communicative competence" along with the teaching of purely linguistic form. Paulston[5] discusses the concept of communicative competence and the rationale which makes it a necessary part of language learning and instruction. Paulston points out that communicative competence may be viewed on two skill levels. On one level communicative competence is equated with the ability to interact linguistically with users of the target language. At this level the language learner has learned or been taught the performance of speech acts in the sense of Austin[6], Ross[7] or Searle[8], language used by speakers for more than the simple conveying of information, language employed to make requests, invitations, promises, refusals and the like. As it turns out it is often only the requesting and giving of information that receives any serious or consistent treatment in courses in a second language. Even fairly advanced students of a foreign language can often do little more than ask and answer questions. There have, of course, appeared texts and courses in recent years which have sought to reverse the trend.

Paulston argues, however, that even the teaching of linguistic interaction is insufficient to the development of full communicative competence in a second language. Paulston insists in addition on providing the learner with the "social meaning" of the linguistic forms (i.e. what kinds of questions are polite socially and culturally and which are not).

What Paulston argues as essential in the instruction of the spoken, colloquial language can also be argued for in the teaching of EST: in addition to the production and interpretation of literal and purely linguistic forms, the performance and interpretation in the appropriate contexts of the speech acts of EST, one of which I have argued in this paper is the EST argument.

FOOTNOTES

1 "Critical reading" refers to reading which employs inferential and evaluative skills.

2 Grice, H. P. The logic of conversation, manuscript, 1968.

3 Gordon, David and George Lakoff, Conversational Postulates, manuscript, undated.

4 Searle, John, "Indirect Speech Acts", lecture given at the LSA Linguistic Institute, June 28, 1974.

5 Paulston, Christina Bratt, Developing Communicative Competence: Goals, Procedures and Techniques. T.E.S.O.L. 1974.

6 Austin, J. L., How to Do Things with Words. Oxford, 1962.

7 Ross, John R., On Declarative Sentences, manuscript, 1968.

8 Searle, John. Speech Acts. Cambridge University Press. 1969.

FIGURE 1

In the seventeenth century, long after the invention of the vacuum pump, a device for raising water from one level to another, it was well-known that such a vacuum pump could not raise water higher than 35 feet. The problem that faced scientists was the question: Why was it impossible to raise water higher with a vacuum pump?

In the seventeenth century, Torricelli hypothesized that the atmosphere had weight and exerted pressure on objects on the earth's surface. He reasoned that if this were true, a liquid such as mercury, which was 14 times heavier than water, could be raised only 2.5 feet by what he supposed to be "air pressure."

In order to test his hypothesis, Torricelli took a glass tube somewhat over 30 inches long and closed at one end. He filled the tube with mercury. Then he put his thumb over the open end of the tube. He turned the tube upside down and inserted the open end in a cup of mercury. The liquid in the tube fell until its top was only about 30 inches above the surface of the liquid in the cup. The mercury stayed in the tube because of the pressure of the air on the surface of the mercury in the bowl.

Torricelli concluded that his hypothesis was correct. He explained this by theorizing that the atmosphere of the earth was like a "sea of air" which had weight and therefore exerted pressure on objects on the earth's surface.

FIGURE 2

1. Statement of the problem
2. Statement of the hypothesis
3. The consequences of the hypothesis
4. The evidence/results
5. The conclusion

FIGURE 3

PROBLEM:

Albert Michelson...and...Edward Morley began a series of experiments designed to measure the velocity of the earth as it moved through the allegedly stationary ether.

CONSEQUENCES:

According to the ether theory, the speed of a light pulse is c relative to the ether. If the apparatus is moving with respect to the ether, it can partly catch up with the light pulse...The time for the round trip in this case (when the apparatus is oriented along the direction of motion) is called t'.

When the apparatus is at right angles to the direction of motion the light has to follow the triangular path shown (in an accompanying illustration) in order to return to the lamp. The time required to go from the lamp to the mirror and back to the lamp is called t".

The crucial conclusion is that when the earth's velocity is not zero with respect to the presumed ether, t' and t" are necessarily different and, in fact, t' is larger than t".

TEST/RESULTS:

The essence of the experiment is to launch two steady light beams at right angles along distances that are as nearly equal as can be made in practice. The light beams travel up their respective paths, bounce off mirrors, and return to their source. Now if this apparatus is stationed on the earth and is moving through the ether, then the two light beams can't return to the central point simultaneously. This effect can be measured with great accuracy because, ..., the two light beams would interfere with each other, thereby producing characteristic interference fringes of the type discussed in other chapters. The two arms cannot be made exactly equal in length. Michelson rotated the apparatus between measurements to make first one arm and then the other point along the direction of motion, then he looked for a change in the interference pattern.

However, when the experiment was performed Michelson and Morley found nothing! There was no effect. Michelson and Morley repeated their experiment several times and it has been repeated a number of times in recent years with modern techniques. And neither they nor any other observers have been able to discover the slightest effect of the earth's motion with respect to a hypothetical ether.

----Concepts in Physics. CRM Books,
Del Mar, Calif.. 1973. pp. 153-154.

FIGURE 4

1. Find a problem
2. Hypothesize a solution
3. Deduce the consequences of the hypothesis
4. Test the hypothesis against its logical consequences
5. Observe the results
6. Reach a conclusion concerning the validity of the hypothesis

FIGURE 5

I. INTRODUCTION
II. THE EXPERIMENT
   A. APPARATUS
   B. PROCEDURES
III. RESULTS
IV. DISCUSSION

FIGURE 6

APPLICATION OF THE METHOD

The Problem: The problem that must be solved is this: If you are going to buy new tires for your car, what kind of tires will give you the best traction on a smooth surface --- rough-tread tires or smooth-tread tires?

The Hypothesis: Make a hypothesis of the solution to the problem. Write it below:

Consequences of the Hypothesis: If a block of rubber with sides made to simulate rough and smooth tire treads is placed at the top of an inclined plane, the side with the greatest traction will slide down the plane more slowly than the side with the least traction.

The Test: Perform a test of the hypothesis.

The Results: Describe your observations of the results below:

The Conclusion: Reach a conclusion concerning the validity of your hypothesis:

FIGURE 7

MATCHING PROBLEM. On the left you will find the six steps of the scientific method. On the right you will find statements about John Dalton's experiment, but they are not in the correct order to match the steps in the scientific method. In the space to the left of each step in the scientific method write the letter of the statement which expresses that step in the method. Number 6 has been done for you as an example.

__1. Problem

__2. Hypothesis

__3. Consequences

__4. Test

__5. Results

F 6. Conclusion

A. Materials combine in definite proportions because all matter is made of tiny particles with definite weight.

B. Carbon and sulfur were observed to combine with oxygen in either of two ways in a ration of simple whole numbers.

C. Materials always combined in the same proportions by weight.

D. If matter is made of tiny particles with definite weight, two materials which combine in more than one way always combine in a ratio of simple whole numbers.

E. Carbon and oxygen were combined to form carbon monoxide and carbon dioxide. Sulfur and oxygen were combined to form sulfur dioxide and sulfur trioxide. The materials were weighed before and after combination.

F. The hypothesis is validated.

FIGURE 8

Madame Curie's experiment provided evidence that atoms contain both positive and negative particles. You will find below an outline of her experiment. The problem, hypothesis and deduction of consequences have been given. You complete the outline by describing the test, stating the results and giving the conclusions.

I. PROBLEM. A sample of pure radium quickly becomes contaminated with other elements, even when isolated.
II. HYPOTHESIS. The contamination occurs because atoms of radium throw off positive and negative particles thus changing the radium into other elements.
III. CONSEQUENCES. If radium throws off positive and negative particles, then these particles should be attracted by positively and negatively charged plates.
IV. TEST.
V. RESULTS
VI. CONCLUSIONS.

FIGURE 9

INSTRUCTIONS: Read the following passage and write a conclusion concerning the validity of the hypothesis that is discusssed.

Rutherford's demonstration that an atom consists of negative particles at great distances from a positive core posed immediately the question what keeps the electrons from falling into the nucleus? A possible answer was motion in elliptical orbits. Just as the moon is prevented from falling to the earth by the centrifugal force of its motion, so perhaps the rapid motion of each electron around the nucleus counter-balances the electrical attraction between them.

But this idea presents difficulties. According to Maxwell's theory, an electron somoving should emit electromagnetic radiation continuously. Giving out radiation means that it should continuously lose energy, its orbit should become steadily smaller, the wave-length of its ratiation should grow longer, and at length it should collide with the nucleus. Now electrons simply do not act that way, Maxwell's theory or no Maxwell's theory.

----Krauskopf, Konrad Bates, Fundamentals of Physical Science, Fourth Edition. McGraw-Hill Company, Inc. (1959). pp. 334-335