EVALUATION OF A CONTENT COMPREHENSION APPROACH TO READING ENGLISH FOR SCIENCE AND TECHNOLOGY

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Introduction

ESP materials developers are frequently called upon to develop language materials for narrowly defined fields of study. Too often the language of the "target" texts which form the basis of the course is viewed as a product which the learners must master rather than as the stimulus for a complex set of interacting learner strategies and tasks embedded in the learning process. In part, this reflects a view that texts are linguistic objects rather than vehicles for the presentation of information (Johns and Davies, 1983). That is, the passages are considered to be objects representing organizational or syntactic structures to be studied and mastered by students. However, such topological approaches may lead to strict bottom-up and discrete views of teaching and learning. The present study reports on an ESP approach designed to incorporate the learner's motivation to gain information into the process of learning to read science and technology texts in English. Here the central focus of English for Science and Technology (EST) is the interaction of the learner reading strategies and the reading tasks the learner performs. That is, EST is seen within the context of the reading process, and authentic EST reading involves using the text to gain information.

The context of this study is the Reading English for Science and Technology (REST) Project in the Chemical Engineering Department of the Universidad de Guadalajara (UdeG). This is a joint project between the UdeG and the University of California at Los Angeles. The students are in their third and fourth years of a five year course leading to a degree in Chemical Engineering. The EST courses are not compulsory. Rather, they are elective courses offered in the University five hours each week. The students have no particular desire or perceived need to learn English other than in order to gain information from journal articles, manuals and textbooks in their university

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studies and future jobs. The students are "false beginners" in that they have had four to five years of general EFL instruction in their preparatory and secondary schools prior to enrolling in the university.

The discussion will present: (1) the theoretical bases for a reading based model to EST instruction as exemplified by the REST Project; (2) some implications of the approach for materials selection; (3) the process of implementing the approach; and (4) a discussion of student performance. Finally, it will discuss the implications of seeing EST, or ESP in general, within the context of the comprehension process, whether reading or listening.

A Content Comprehension Approach to EST Reading

A content comprehension approach for EST reading instruction places primary emphasis on the learner's purposeful interaction with the text. In order to understand the concerns of this approach, it is useful to briefly note those approaches to ESP that the REST Project did not adhere to. (Cf. Hutchinson & Waters, 1987; Swales, 1985, 1988; Lynch and Hudson, in press for more exhaustive discussions of the alternate views taken to ESP). First, the REST Project did not view EST in the present context as primarily a language or structure issue. That is, it did not view EST as a special language identified by a special grammar and register (Swales, 1971). Nor is the project linked to a rhetorical approach which organizes materials around reading genre or organizational patterns such as comparison and contrast, classification, etc. (Trimble, 1985). Second, it was not assumed that EST could be completely captured through target situation analysis (Munby, 1978). As Long (1985) has noted regarding needs identification in general, target situation analysis may focus on linguistic terms alone. Nor was it assumed that an approach which places importance primarily on general language learning concerns rather than reading would be adequate (Hutchinson and Waters, 1987). This should not be taken as a claim that the above are unimportant considerations. However, needs are defined by more than the target situation. The process of instruction must involve more than approaching language as a product to be mastered; it must additionally recognize that the language learning process itself should fit tasks which are authentic to the specialist area (Long, 1985; also, cf. Swales, 1988 for a thorough discussion of competing views of ESP emphases). **Purpose** is a central concern of ESP, but purpose does not reside in the text. It resides in

the language learner's relationship to the learning task. That is, purpose is a function of the student's need to actually understand the text and future texts on similar topics.

By approaching EST reading through the comprehension of information, the approach described here places the language learning within a cognitive process. Reading is not a process of exact identification of letters, words, and ultimately sentences leading to comprehension built from letter to word to phrase to sentence (Goodman, 1967). Rather, people read for meaning and comprehension by relating new information to what they already know. Readers make use of their existing schemata to make predictions about what is coming next in the text and about how some new, unfamiliar piece of information relates to what is already known (Rumelhart & Ortony, 1977; Rumelhart 1980). It is clear that low level decoding skills are important for comprehension and are used by readers in interaction with high level skills of meaning generation (Rumelhart, 1977; Grabe, 1985; Eskey 1987). Schemata can be formal knowledge of language structure and organization or can be content knowledge of specific information and events (Carrell and Eisterhold, 1983). However, it is equally clear that readers engage in reading in order to gain knowledge. That is, readers read in order to make their content schema more robust, not usually to augment their formal language schema.

With the content comprehension approach taken in the REST Project, EST is seen within the context of reading. Authentic EST reading involves interacting with the text in order to gain information and reduce uncertainty. Consequently, EST is seen as focusing on the interaction of the learner reading strategies and the tasks the learners are to perform. In terms of the tasks with which the learners are or will be engaged it is important to focus on what the learners actually do with a text. With an emphasis on content comprehension the REST approach exploits the fact that real world reading involves reading for a purpose. In terms of learner strategies, emphasis is placed on utilizing the learner's existing processes and on leading learners toward principles of coping with text. Such a focus on learners interacting with text, not specifically on the language structure, entails a need to consider the learner's processing strategies as well as the language object which will be dealt with.

Implications of the content comprehension approach for materials selection and use

There are three implications of the content comprehension approach for materials selection and use. These pertain to the authenticity of the material to be used, the thematic basis for text organization, and the derivation of instructional points. The association of these three is in terms of the relation of each to the reading process.

An issue for materials selection concerns the role of authentic materials in the curriculum. Most justifications for the use of modified or simplified materials have focused on allowing the students access to the language form and thus to the content of the text. However, there are several arguments in favor of the use of authentic materials throughout ESP programs (Lynch & Hudson, in press), three of which appear particularly important in the context of EST. First, when material is simplified or modified, it is often changed in ways that may make the material more difficult (Fillmore, 1981). That is, there are no clear guidelines for the simplification of material, and when material is simplified to reduce the sentence length or complexity, frequently the cohesive elements of the text are reduced such that relationships between ideas are lost. Additionally, modified or simplified material may change the nature of the text. While interacting with this text the student may develop strategies which work well with modified texts but are not transferable to unaltered texts of the type they will need to read. Research has shown the importance of metacognitive awareness in the reading process (Devine, 1984; Barnett, 1988; Carrell, 1989). Simplified text may interfere with the successful application of the reader's skills. Third, simplified material is too frequently developed with no real-world task in mind. If students will eventually need to examine a catalogue to find the most appropriate transistor for a particular use, then the best method of teaching the students that skill is to have them actually use a catalogue for ordering transistors.

A second implication of the approach to EST indicated above is the need for a topic basis for readings. A topic or thematic based curriculum maximizes the interaction of learner strategies and text task, as well as helping create more semantically robust background knowledge. There is a schema basing of material which promotes the utilization of the reader's background knowledge in the comprehension process. Part of that background knowledge is the

knowledge that when one reads in the real world, one reads materials on a given topic and for a particular reason. Further, individuals tend to read content on similar topics during any particular period of time. An educational approach that focuses on language learning alone, ignoring the learning of subject matter, is inadequate to the needs of language learners (Mohan, 1986). It is central for students to see what they can and cannot do while working with texts to gain content information. There are several methods of going about developing topic/content based materials. If the reading program is an independent course, then the curriculum content can project what types of materials the students will eventually be required to read. However, if the program is found within an existing diversified course of study, such as engineering, chemistry, medicine, or architecture, the content of the ESP course can be determined by the course materials that the students are studying in their content courses.

A third implication is that the points of instruction emerge from the reading task. That is, the instruction directed to grammar, vocabulary and rhetorical structures arise from a need to process the text and carry out the task. Additionally, reading skills activities such as skimming, scanning, reading for meaning, activating schemata, etc., come from a task which requires that skill to be used. The texts should be selected for content rather than in order for students to practice a particular structure or skill. Barnet (1988) has indicated that explicit reading skill instruction per se may be ineffective. That is, there is little evidence to indicate that isolated reading skill practice is any more effective than isolated grammatical pattern practice in terms of communicative performance. By deriving the points of instruction from the reading tasks, instruction is more attentive to the processes and strategies that the student must learn than to mastery of separable language products such as a particular rhetorical style or a particular grammatical structure.

The REST Project as an example content comprehension approach

The REST Project employs a modified "adjunct model" of ESP instruction (Brinton, Snow and Wesche, 1989). The materials for the two year course are developed around ten thematic units which correspond to course content in the Chemical Engineering undergraduate program. These themes are

presented in Figure 1.

Figure 1. REST Project Thematic Units

Year One:

1. General Science/ Physics and Chemistry
2. The Field of Chemical Engineering
3. Energy
4. Materials and Properties
5. Environment: Technical issues and solutions

Year Two:

6. Technology
7. Electronics
8. Computers
9. Equipment Design
10. Physical and Mechanical Processes

Although the themes evolved from a close examination of the required syllabus in the chemical engineering major, the first two units of Year One are very much schema based. Since the REST course begins in the third year of a five year content sequence, the students have a background in general science and have spent some time thinking about their future careers. However, the students have not begun their specialization within the Chemical Engineering field. As noted above, although they have all studied English for several years in secondary school, they are for the most part false beginners with little functional ability in English. Thus, the articles in the first two units of year one focus on general science material which is already known. For example, a straight-forward description in English on the method of science is relatively easy for the students to read given that they already know the material and that there are many cognates between Spanish and English.

The thematic materials developed for each of the content-based units comprising the REST curriculum are technical selections dealing with topics that could well be assigned in one of the required courses for the major. The materials in the remaining units of Year One tend to be content from courses that the students have already taken as part of their studies. Throughout the

two years of the REST course, they frequently read materials which cover known information. Thus, they have the content schema for the articles and become confident about reading English. The later units in the second year of the course cover material that the students are currently, or will soon be, studying. The focus on course design thus shifts to relevance for their future professional preparation.

The materials design process in the REST Project is perpetually on-going. Authentic articles and authentic tasks are identified. As the materials are selected, text criteria are developed for each thematic unit. Text selection emerges from this set of criteria and in that process the criteria may be altered as the materials developers learn more about the themes and the students' content needs. Examples of the text criteria for the fourth unit of Year One and Year Two are provided below in Figure 2 and Figure 3 (adapted from Smith, 1988).

The text criteria attempt to include information about the language content as well as information regarding the language processing and learning of the students. For example, the criteria in Year One require that there be "readables" in the materials selected. These "readables" are texts whose content the students already know. This is less an issue in Year Two when students have more developed reading proficiency. Additionally, the texts are selected to reflect student background knowledge and be applicable in the Mexican context. An example of how the text criteria for the different units differ can be seen in the Article Content section of the two units presented in Figures 2 and 3. In the Year One unit, the content is general in nature in order to avoid focusing on one particular property while in the year two unit the materials which are called for are to be very specific. This particular distinction is based on the types of content to be covered in the two different units as much as it is based on the difference in reading proficiency between the two years.

An example of the use of the materials selected on the basis of the unit criteria from Figures 2 and 3 is provided in the Unit Flow Charts in Figures 4 and 5. It should be mentioned that the articles were selected by the students from among those in a larger collection of passages related to the unit topics. They went through the larger selection and determined which passages they wanted to read. In this way they practiced skimming and scanning as a

purposeful activity.

Figure 2. Unit criteria for Unit IV of Year One text selection.

YEAR ONE
UNIT IV: PROPERTIES AND MATERIALS
UNIT CRITERIA

MATERIAL IS NOT DATED
- texts no older than 1984–5 unless content is not liable to date too quickly

RELEVANT TO MEXICO
- properties and materials should deal with activities of interest in Mexico

ARTICLE CONTENT
- content relates to unit theme concerning the properties of materials
- content should be general in nature and avoid very specific and prolonged discussion of any one single type of material
- content should reflect student background knowledge

UNIT "READABLES"
- general article concerning basic chemical properties and materials: "Iron and the Steel Alloy Metals"

LENGTH
- varied length across articles
- one to eight pages in length

ARTICLE CHARACTERISTICS
- little idiomatic usage
- articles have appropriate subtitles and sub-divisions
- good use of graphs, charts, illustrations
- articles demonstrate good scientific writing (ideas and details clearly presented, easy-to-follow argument)
- grammar not prohibitively difficult

Figure 3. Unit criteria for Unit IV of Year Two text selection.

YEAR TWO
UNIT IV: EQUIPMENT DESIGN
TEXT CRITERIA

MATERIAL IS NOT DATED
- no obsolete equipment design issues
- texts be older than 1984 if they cover general equipment concepts still relevant

RELEVANT TO MEXICO
- include authors from Mexico when possible
- all articles adequate for the needs of the country.

ARTICLE CONTENT
- content relates to unit theme of Equipment Design.
- content should be specific in nature so each text can be studied separately as a different design with all its processes and design specifications.
- content should reflect student background knowledge or a general idea of the design

LENGTH
- 4 to 13 pages
- students continue reading longer texts

ARTICLE CHARACTERISTICS
- articles should contain little idiomatic usage, but students should understand those idioms that are used
- extensive technical vocabulary, appropriate to each text
- unit vocabulary list not appropriate for this unit because of the diversity of topics
- articles have appropriate subtitles and divisions
- good use of graphs, charts and illustrations.
- articles demonstrate good technical writing
- ideas and details clearly presented.

Figure 4. Unit Flow Chart for Year One Unit IV.

YEAR ONE
UNIT IV: PROPERTIES AND MATERIALS
UNIT FLOW CHART

1. Here's Something to Chew on, *Advanced Materials and Processes*. February 1988. p. 6.
   - prediction and previewing strategies
   - skimming/scanning for and summarizing main ideas and supporting information
   - vocabulary: parts of speech as strategy
2. Iron and Steel Alloy Metals. Hess, F.C., and Thomas, A.L., *Chemistry Made Simple*. pp. 142–149.
   - prediction and previewing: known topic information
   - scanning for comprehension of details
   - vocabulary: matching
3. Currents in Plastics. *Scientific American*. September 1987. p. 22.
   - prediction and previewing
   - skimming to find predicted main ideas
   - finding supporting information for main ideas
   - grammar: logical connectors
4. Plastics That Conduct Electricity. Kaner, R.B. and MacDiarmid, *Scientific American*. February 1988. pp. 106–111.
   - prediction and previewing
   - summarizing main ideas and important information
   - vocabulary in context and matching: grammar: review of *modal + passive*
5. The New Superconductors: Prospects for Applications. Wolsky, A.M., Giese, R.F. and Daniels, E.J. *Scientific American*. February 1989. pp. 44–52.
   - prediction and previewing
   - skimming for main ideas
   - scanning for important information
   - grammar: matching review of previous grammar
6. Streetsmarts—Peroxide-Cured Gaskets in Plate and Frame Heat Exchangers. Baker, G. and Marthur, A.P., *Chemical Engineering Progress*. July 1988. pp. 12–14.
   Streetsmarts—Flexible Joints Reduce Piping System Damage. Magner, R. *Chemical Engineering Progress*. September 1988. pp. 16–18.
   - understanding main ideas and important vocabulary
   - student generated quizzes for scanning for main ideas,vocabulary in context, part of speech/grammar review

Figure 5. Unit Flow Chart for Year Two Unit IV

YEAR TWO
UNIT IV: EQUIPMENT DESIGN
UNIT FLOW CHART

1. Liquid Storage in the CPI, Newton, P., Von Tress, W.R., and Bridges, J.S., *Chemical Engineering*, April 3, 1978, pp. 9–15.
   - vocabulary development: Eng/Spn, Eng/Eng
   - comparison of tanks, vessels, type
   - skimming comprehension questions
   - (WITHOUT text) describe in either Eng/Spn 6 vessels discussed in text

2. Extending the Life of Tubular Heat Exchangers, Yokell, S., *Chemical Engineering*, July 20, 1987, pp. 74–86
   - study vocabulary: Eng/Spn, Eng/Eng
   - prediction through translation of title and 1st 2 paragraphs of text
   - key vocabulary items within text and define them in Spanish
   - problem/solution issues in passage
   - complete decision flowchart
   - write summary of decision process for one of three problems

3. Speed Up Heat Exchanger Design, Robles Guzman, Pedro E., *Chemical Engineering*, March 14, 1988, pp. 143–146
   - write predictions for THREE topics they expect to see in the text
   - depth reading through generating comprehension questions in either English or Spanish for
   - summarize the author's purpose for writing article
   - follow-up on prediction by stating whether or not predictions were in the text and if they were, where?

4. Packed Column Internals, Chen, G.K., *Chemical Engineering*, March 5, 1984, pp. 40–51
   - study vocabulary: Eng/Spn, Eng/Eng
   - skimming and depth reading through comprehension questions
   - description of devices and their functions

Through the flow chart, the articles which have been selected are viewed as a thematic unit of information the students can learn, and an overall reading component is constructed. At this point, the texts are viewed individually to determine what tasks will help lead the student to the content of the text. Appendix A provides a sample of the materials developed for the second text during Year Two. These materials are designed to help the student read the passage for comprehension. The particular text presented here is a twelve page text which requires a great deal of processing in order to use the information presented. First, in sections I, II, and III the students work with enabling vocabulary and prediction activities. These serve as set-up activities for the reading the students will do. Step IV guides the students through skimming the two focal sections of the article. Step V focuses the students on the information for solving problems which the text addresses. Step VI then guides the students through a very dense section of the text. The decisions which the students supply are key concepts in carrying out the operations presented in the passage. Finally, in Step VII, the students provide a summary of one topic in the passage. This is the type of knowledge any reader of this text would expect to have after reading the passage.

It should be clear from the above discussion that the focus of the materials development process was to provide the students with the ability to comprehend the content of materials they needed for their studies. Grammar, rhetorical structure and vocabulary treatment emerge from the texts themselves. The target situation is defined in terms of reading comprehension skills as they emerge from the texts. Finally, the purposes for the activities emerge from the purposes that the students would authentically have with these types of reading tasks.

The REST Project and student achievement

A reasonable concern about a content comprehension approach to reading relates to whether other language abilities are improved. Earlier approaches have argued that focusing on the special grammar or structure of ESP texts will improve comprehension. What has not been addressed in the past is whether the converse can be true. That is, if grammar or global reading ability are not the focus of instruction, can they improve through a focus on content

comprehension? The answer to this question is the focus of this study. Lynch (1987) indicated the effectiveness of the general REST ESP model over a non-ESP based approach to instruction employed with a control group at another campus of the UdeG. The present evaluation is concerned with two questions related specifically to the REST content comprehension approach.

1) Can the emphasis on reading skills utilized in the Project improve reading comprehension?
2) Do grammar and general ability skills improve in addition to reading comprehension ability?

The subjects comprised the 364 REST Project students at entrance (no instruction) or exit (two academic years of instruction) between 1987 and 1989. Students were administered one of three reading comprehension tests at the beginning and end of each year. Different forms were used for the entrance tests and the exit tests. Each form included a 30 item contextualized grammar test, a 10 item reading comprehension test and a 25 item general ability multiple-choice cloze test. Reliability coefficients for the three forms are KR20=.89 for Form 1, KR20= .90 for Form 2 and KR20= .84 for Form 3. The means and standard deviations for percent correct scores on the three forms of the test are presented in Table 1. The scores are higher for the instructed group than for the uninstructed group on each subtest of each test form. The reading comprehension subtests have means higher than the other subtests for both the uninstructed and instructed groups across all forms of the test.

Table 1
Means and standard deviations for instructed and uninstructed students on test forms 1, 2 and 3.

FORM	Subtest	Uninstructed	Instructed	Total
		n=71	n=28	n=99
	Grammar	44.81	56.55	47.81
		(16.17)	(16.39)	(17.06)
1	Comprehension	61.83	72.14	64.75
		(19.15)	(17.92)	(19.29)
	MC Cloze	40.62	59.86	46.06
		(20.50)	(17.92)	(21.74)
		n=112	n=31	n=143
	Grammar	41.40	67.42	47.04
		(16.59)	(13.71)	(19.25)
2	Comprehension	53.84	85.16	60.62
		(26.52)	(14.58)	(27.61)
	MC Cloze	41.46	65.16	46.60
		(17.32)	(12.44)	(19.06)
		n=29	n=93	n=122
	Grammar	43.56	68.03	62.21
		(13.60)	(14.00)	(17.35)
3	Comprehension	56.21	80.32	74.59
		(23.67)	(10.37)	(17.82)
	MC Cloze	42.62	53.59	50.98
		(09.87)	(14.23)	(14.09)

The correlations among the subtests for each test are presented in Table 2. The grammar and multiple-choice cloze subtests tend to have the highest correlations. The reading subtest tends to have lower correlations with the other two subtests, but does not consistently correlate more highly with one than with the other.

Table 2
Correlations of subtests on each form of the test.

		Uninstructed		Instructed		Total	
FORM	TEST	GRAM	READ	GRAM	READ	GRAM	READ
	GRAM	1.000		1.000		1.000	
1	READ	0.517	1.000	0.207	1.000	0.476	1.000
	CLOZ	0.602	0.509	0.808	0.416	0.698	0.529
	GRAM	1.000		1.000		1.000	
2	READ	0.504	1.000	0.525	1.000	0.630	1.000
	CLOZ	0.652	0.615	0.542	0.554	0.739	0.701
	GRAM	1.000		1.000		1.000	
3	READ	0.499	1.000	0.404	1.000	0.613	1.000
	CLOZ	0.421	0.234	0.637	0.383	0.649	0.414

In order to examine the gain scores and the inter-relationships among the subtests, a repeated measures multivariate analysis of variance (MANOVA) for each test is shown in Table 3. On all three forms of the test, there is a significant difference ($p < .05$) indicated for STATUS (instructed vs. uninstructed) and for SUBTEST (grammar, reading and cloze). On Form 3 there is also a significant interaction for SUBTEST by STATUS.

Table 3
Repeated Measures Anova Tables for each form of the test.

Source	df	Sum of Squares	Mean Square	F	p
FORM 1:					
Between Subjects Effects					
STATUS	1	11656.5931	11656.5931	16.85	0.0001
Error	97	67103.7780	691.7915		
Within Subjects Effects					
SUBTEST	2	14827.6961	7413.8481	45.41	0.0001
SUBTEST*STATUS	2	889.9004	444.9502	2.73	0.0680
ERROR	194	31670.9765	163.2525		
FORM 2:					
Between Subjects Effects					
STATUS	1	53151.6211	53151.6211	68.14	0.0001
Error	141	109979.7087	779.9979		
Within Subjects Effects					
SUBTEST	2	15894.5250	7947.2625	46.13	0.0001
SUBTEST*STATUS	2	741.7045	370.8522	2.15	0.1181
ERROR	282	48587.1554	172.2949		
FORM 3:					
Between Subject Effects					
STATUS	1	26133.0647	26133.0647	72.44	0.0001
Error	120	43288.6439	360.7387		
Within Subject Effects					
SUBTEST	2	18303.5917	9151.7959	81.82	0.0001
SUBTEST*STATUS	2	2616.0969	1308.0484	11.69	0.0001
ERROR	240	26845.4623	111.8561		

In order to determine whether there remained a significant main effect on

the subtests for the instructional status, Scheffe post hoc tests for differences between means were computed. These are shown in Table 4 and indicate that there was a significant difference for each subtest by instructional level on each of the three test forms.

Table 4
Scheffe comparison mean differences between instructed and uninstructed examinees.

Form	Test	df	minimum significant difference	difference obtained
1	Grammar	97	7.189	12.182*
	Reading	97	8.333	10.312*
	Cloze	97	8.868	19.237*
2	Grammar	141	6.427	26.020*
	Reading	141	9.817	31.322*
	Cloze	141	6.583	23.687*
3	Grammar	120	5.856	24.466*
	Reading	120	6.147	24.116*
	Cloze	120	5.618	10.970*

The results show significant improvement by the students in all three skill areas measured by the tests. Thus, a content comprehension approach in which students are not presented a structurally based syllabus can help students improve their grammar and general reading language ability.

Although there are significant differences associated with instructional status, there are two anomalies in the results. The most obvious is the interaction of subtest by status indicated in Form 3 of the tests. This appears to be due to a lower improvement in cloze scores than the relatively large gain in the scores on the other grammar and reading subtests. The reason for this low improvement, in contrast with the other test forms, is not clear. The second anomaly is the relatively low improvement in reading comprehension on Form 1 of the tests. In fact, there was low improvement on all three subtests relative to Form 2 and 3. This general low improvement may be due to one of two factors. First, Form 1 was a form of the test administered early in the program

of materials development articulated above. The instructed students who took this form received early pilot versions of the instructional materials. Many of the materials they received were eventually deleted or radically changed. Second, there are only 28 instructed students for this form of the test. Given the relatively large standard deviations in comparison to the other two forms of the test, the distribution of scores in this group may be creating the low differences. That is, a single very low score could affect the instructed mean scores strongly. Both of these anomalies need further analysis.

Conclusions

The REST Project curriculum presented in this study is based on a concern for motivating students with relevant, authentic reading materials as well as a concern for applying current reading theory to foreign language reading instruction. In this context, this implies that students receive instruction in language structure, listening, speaking and writing only as these serve to enforce the students' ability to read technical English. The goal of the project is that the students become autonomous readers in the field of chemical engineering by the end of their second year in the project.

This evaluation has indicated that the content comprehension approach can significantly improve the reading comprehension of students as well as improve their grammatical and general reading ability. The implications of these findings are not that other approaches to instruction and syllabus design are either ineffective or logically flawed. Rather, the implications are that a reading comprehension approach can be an effective basis for a program to improve reading ability and at the same time not do disservice to other language components.

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APPENDIX A

Materials Developed for Year Two, Unit Four, Text Two

"Extending the Life of Tubular Heat Exchangers"
Chemical Engineering, July 20, 1987, pages 74-86

I. Vocabulary List: Read the following vocabulary list for this article. Some of the expressions are defined in Spanish. Others are defined in English.

English - Spanish

baffle - tabique, división, placa de desviación, deflector
base load - carga fundamental
to blanket - amparar, cubrir, tapar, cubrir con manta
bolt - perno, otrnillo, clavija
bottleneck - cuello de botella (dificultad, impedimento)
bypass - sobrepaso, cortocircuitar
chamfer - chaflanar
drain - desaguar
to excise - cortar, quitar
feedstream - corriente de alimentación
flange - saliente, reborde
groove - acanaladura, ranura, estría
peak service - periodo de máxima demanda
plug - tapón, oturador, tapador, tapadero
shell - revestimiento
sludge - cien, fango, lodo, barro, sedimentación
straightforward - sencillo, directo al grano
to purge - limpiar, purgar
ratchet - trinquete, carraca, gatillo, matraca, chicharra, cric
vent, vented - respirado, con respiración
vessel - caldera
worn, worn-out - gastado, inservible

English - English

employ - use
restart - start again
shutdown - terminate operation
startup - begin operation

II. Interpretation: Translate the title and the first two paragraphs of the text into your own words in Spanish.

A) Title

B) Paragraph One

C) Paragraph Two

III. Vocabulary in Context: Find the following terms. Write their definitions in either English or Spanish.

EXAMPLE: mothballing (page 74, col. 1) = "successfully shutting down for long periods without deterioration."

1. retubing (75/2)

2. rebundling (75/2)

3. retrofitting (75/2)

4. heat-location maps (77/1)

5. tube-plug map (77/1)

6. sleeving (79/1)

7. heat shield (85/2)

IV. Comprehension: Use the text to answer the following questions in Spanish. The items are NOT in text order. The answers should be complete and contain ALL the important details.

1. What is the procedure for mothballing if it is NOT safe to fill the exchanger with process fluids?

2. In rebundling, what should be done if the shell and bundle have been changed and deviate from the original plans?

V. Chart: Use the text to complete the following chart. You may answer in either English or Spanish but the answers must be complete.

TUBING RETROFITS

1. when a more corrosion resistant material is used

PROBLEM: does not conduct heat as well as original material

SOLUTION:

2. when the exchanger is retrofit with thicker tubes

PROBLEM: reduces tubeside flow area, thus increasing tube velocity and pressure drop

SOLUTION:

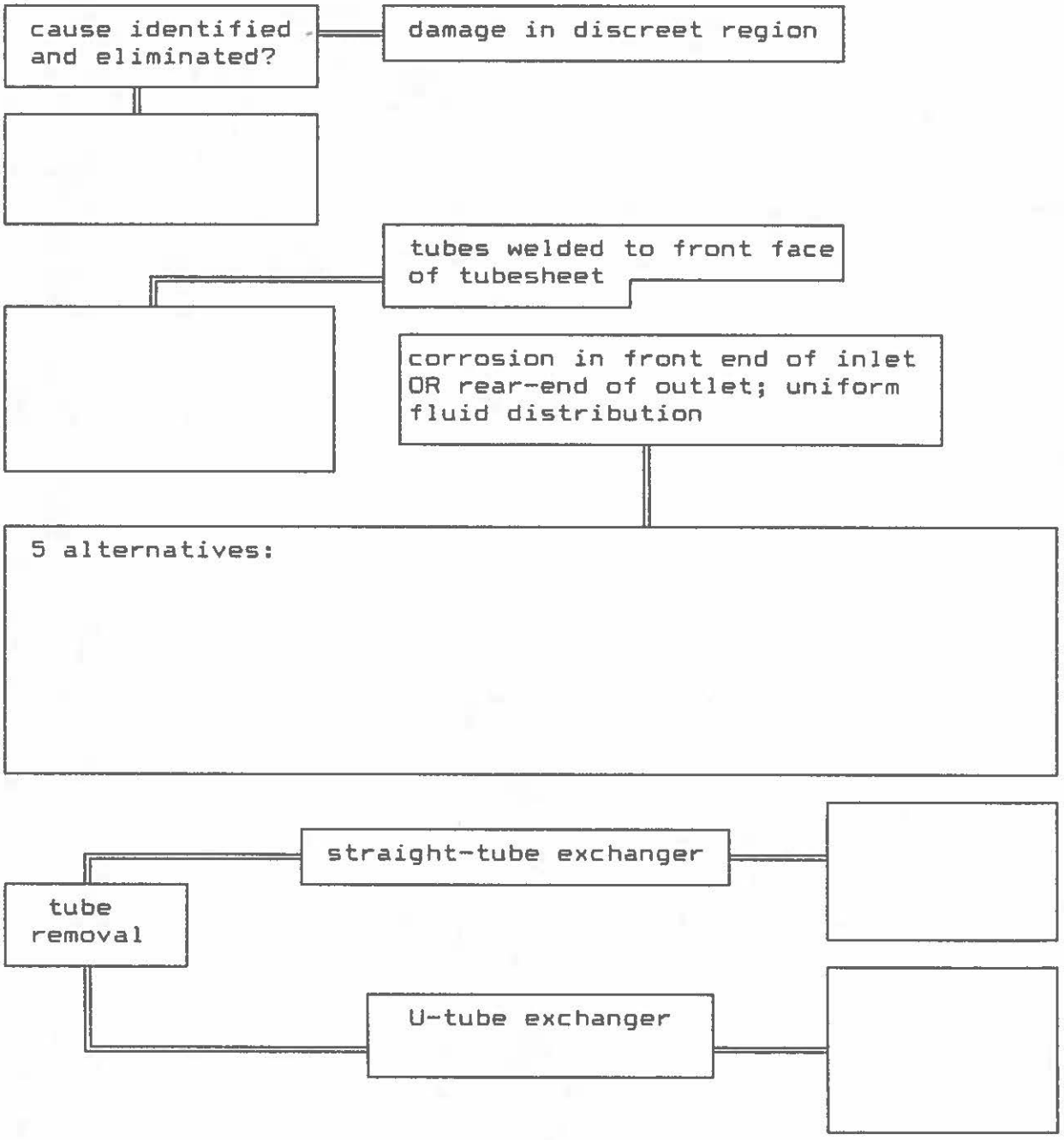
GUARDING AGAINST VIBRATION DAMAGE

3. when the tube thickness is reduced during retrofit

PROBLEM: tubes may become sensitive to flow-induced vibration damage

SOLUTION:

VI. Flowchart: The following is a representation of the decisions that need to be made for partial retubing, pages 79-80. Use the text to complete the chart. You may answer in either English or Spanish. Include ONLY the decisions; don't worry about the specific procedures.



VII. Summary: Choose ONE of the following three topics and summarize the decisions necessary for each topic.

A. retubing: The tube-to-tubesheet joints can be welded. However, the work will be dangerous. There is no work outage scheduled but there could be. The unit cannot be bypassed. A replacement bundle could be ordered but it will take 6 to 8 weeks and there are only 5 weeks of inventory on hand. Summarize the rest of the decisions to be made before retubing, replacing the bundle or replacing the bundle.

B. tube-end plugging: The unit has been in operation for 5 years. There is no hazard to workers. The damage is in the 1st two-three rows near the inlet to the shell. The tube-side pressure is higher than the shell-side pressure. What are the remaining decisions and procedures for tube-end plugging

C. full retubing: Summarize the difference in making a decision about whether to retube or rebundle a large-removable bundle versus retubing or rebundling a fixed-tubesheet exchanger.