A Way of Processing Scientific Textbooks Information and its Influence on Comprehension

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Abstract

Students who are fit to cope with academic discourse develop cognitive and metacognitive skills that enable them to understand information contained in scientific textbooks and

therefore improve their learning process. This study evaluates reading comprehension abilities and deficiencies of a group of university students by analysing a fragment of a scientific text used in one of the subjects. Results show the most frequent difficulties to process information and understand while reading. The group included students with reading comprehension abilities as well as novice readers, unskilled to control and evaluate their own reading process.

Key words: Information, texts, comprehension, higher education.

Introduction

A review of the last fifty years on reading comprehension research shows that there are various theories concerning the reading process (Dubois 1991). For some, the reader comprehends a text when he or she is able to recognize the sense of the words and sentences that conform it. However, others explain how the information contained in the text is integrated to the reader's previous knowledge or schemes of thought and influences the comprehension process (Rumelhart, 1980; Anderson & Pearson, 1984). These authors point out that the reader tries to find adequate schemes of thought to explain the text and manage to understand the information (Quintana, 2000). When the new information is received, the schemes of thought are restructured, adjusted and perfected. Reading is also seen as a transition process between the reader and the text (Rosenblatt, 1976). The meaning extracted from a text will depend on the transactions produced between the reader and text in a specific context (Cairney 1992).

Education researchers currently define reader comprehension as the process of elaborating the meaning of the relevant ideas in the text and relating them to others they already have, a process through which the reader interacts with the text (Otero, 1997; Campanario & Otero, 2000; Sánchez Miguel, 1993; Macías, Castro & Maturano*,* 1999).

Various works have dealt with the subject of reader comprehension from different angles and for various purposes, such as diagnosing students' predisposition to reading (Cadile & Cadile, 2002), analyzing and evaluating the comprehensive reading abilities (Otero, 1997; Macías, *et al.;* 1999, Martínez, Montero & Pedrosa, 2001), determining the factors affecting comprehension (Macías, *et al.,* 1999; Otero, 1990; Alliende, Condemarín & Milicic, 1993) and the mechanisms acting in that process (Areiza & Henao, 2000b). Furthermore, there are those who develop models, procedures and strategies to encourage comprehensive reading (Alzate, 1999; Bernard, Feat, San Ginés & Sabido, 1994; Izquierdo & Rivera, 1997). Most of these studies are aimed at the problems in comprehension at the basic and middle levels of education. Few studies analyze the subject in higher education (Macías, *et al.,* 1999; Greybeck, 1999; Contreras & Covarrubias, 1999).

In higher education specific subject matter is transmitted, and it is understood that students must "comprehend or understand" the contents of the texts (Carlino, 2002). That is, university undergraduates must (or should) have the ability to interpret conceptual subtleties, draw implications and build new semantic networks that show their meta-textual and inter-textual proficiency (Areiza & Henao, 1999). However, we often find students who don't understand what they read due to a lack of the comprehensive reading abilities, among other factors. This is reflected through the limitations they have in generalizing or transferring what they have learnt to different situations from those that gave way to their learning (Vargas & Arbeláez, 2001).

In this sense, Areiza and Henao (1999), point out that many cognitive and metacognitive capacities that imply complex mechanisms are displayed towards the end of high school and even during the postgraduate level. Such aptitudes would be reached at a late stage in the intellectual development (Ugartetxea, 2001), due to which higher education professors should know the students' comprehensive reading abilities. Lacks in this field are what keeps students from meeting the demands of the academic discourse and of the work pace. Some teachers don't see that the reading and writing tasks they demand from them are a part of the academic practice inherent to their mastery of their subject, where they can make their contributions (Carlino, 2002).

Martínez, *et al.,* (2001) have pointed out that 82% of teachers mention comprehension problems in public school students in Argentina, a situation that would be in harmony with the time devoted to reading, since some secondary level students devote less than two hours per day to reading any sort of printed matter (Cadile & Cadile, 2002). As can be expected, unskilled students would be at a disadvantage when facing higher level studies, as reading and understanding to build the global meaning of the text is a central ability that must be mastered, since it is the basis for learning and culture (Paris, Lipson, & Wixson, 1983).

Background

The structure, organization and design of a scientific text can influence the disposition and interest towards reading it. The contributions by these texts to the teaching and learning process in a subject can be evaluated through criteria that will allow their analysis and comparison. In previous papers we have analyzed as one dimension of quality, the unity of scientific texts (Carranza, Celaya, & Carezzano, 2001, Carranza, Celaya, Carezzano, & Herrea, 2002) used in teaching and learning different subjects in the Biological Science major.

After a repeated process of tests and adjustments made to the survey model used for analyzing the printed texts (Carranza & Celaya, 2002; Herrera, Carranza, & Carezzano, 2002), we have detected certain difficulties in students in the way they explore and work with scientific textbooks, which would have a bearing on their academic performance. There were differences in reader comprehension between

groups of students in the major's basic and advanced levels. In general, both groups use the texts with certain limitations and resort, in a partial way, to previous knowledge to integrate the new information. The textual and cognitive proficiency is partially developed in the basic level. The students in the advanced level evaluate and control their comprehension better; however, the metacognitive strategies are developed when there is in an important participation on the part of the teacher (III Congreso de Anatomía del Cono Sur, 2002).

Conceptual background

The specific type of mental operations used by a good reader depend greatly on the text's structure (narrative, expository or scientific). The proficient reader is able to recognize the type of text he or she reads, and thus, updates and broadens his or her conceptual scheme network. This means that the reader must elaborate a meaning of the text in which he or she must take into account the intentions the author has attributed to it and begin a process that, depending on how the reader develops it, will mark a difference between a good reader and one who isn't (Godoy, 2001).

Pearson, Roehler, Dole & Duffy (1992) have proven that proficient readers have defined characteristics, such as: a) Using previous knowledge to give reading a sense; b) Evaluating their comprehension during the whole reading process; c) Performing the necessary steps to correct the comprehension mistakes in face of bad interpretations; d) Distinguishing what is relevant in the texts they read and summarizing the information; e) Constantly draw conclusions. That is, they are capable of understanding some specific aspect in the text from the meaning of the rest (Anderson & Pearson, 1984); f) Making predictions, elaborating adjusted and reasonable hypotheses about what they will find in the text; g) Making questions and taking responsibility for their reading process.

The problems concerning the comprehension of texts are (Benito, 2000):

- The difficulties in working with the information from the text, which the immature reader tends to process in linear fashion and has drawbacks to identify the global aspects within the text.
- The deficiencies in evaluating and regulating their own comprehension. An inadequate control won't allow them to identify the discrepancies between the scientific information provided by a text and the inappropriate concepts they have.

The comprehension of a text is an activity guided and controlled by the readers themselves, but the building up of knowledge is manifested, only in very few cases, as having been determined on their own, due to which the teacher's participation is necessary in the student's approach to the book (Macías, *et al.*,1999). Their own

cognitive resources are displayed in face of the need to solve concrete situations or problems. The degree of consciousness or knowledge the individuals have concerning their cognitive processes is a metacognitive activity (Flavell, 1976; Vargas & Arbelaez, 2001). Metacognition allows the individual to acquire knowledge and besides, the use and control of it (Vargas & Arbelaez, 2001). In this process there are two cases: knowing the purpose of reading (what they are reading for) and the self-regulation of the cognitive activity in order to be able to reach that goal (how they read). The way in which the process and its regulation are performed is determined by the goals that are sought through reading (Contreras & Covarrubias, 1999). The metacognitive proficiency is the link between semantic memory (accumulated throughout the educational cycle) and the procedural memory (which permits to carry out the changes in the conceptualization processes) to reach higher levels of knowledge (Areiza & Henao, 1999).

Work methodology

The work was done on a group of students from the 5th four-month term in the Biological Science major at National University of Córdoba (UNC) in Argentina, in the year 2001. To evaluate the proficiency and possible deficiencies in comprehensive reading, the students were asked to analyze an excerpt from the book *Zoología de los invertebrados* (Zoology of Invertebrates), by Barnes (1989), used in the study of a specific subject. They were handed the printed test with a faithfully transcribed excerpt, containing 252 words (*Times new roman* 12), organized into three paragraphs corresponding to the topic "celom". This topic proposed by the lady Professor responsible for the subject in the 5º four-month term, represents a previous concept of taxonomic and evolutionary value that students have acquired in the previous correlative and must apply and integrate with the contents of the subject.

In accordance with the established instructions, the students-readers had to analyze the following activities: 1) Give an adequate, complete and representative title to the excerpt. These qualities were defined as: Relevance, incorporating terms that indicate the main idea. Complete, distinguishing the most relevant aspects of the main idea. Representative, make reference to the topic's global structure. (According to the topic of the text, they should include terms or synonyms such as: body cavity, structural diversity, metazoans). 2) Highlight the main idea(s) and place the subordinate ideas in parentheses. 3) Elaborate a five-line summary, which should be: coherent, complete and no longer than five lines. That is, it had to show an ordered relationship and sequence of the most relevant ideas in the text, organize the main and subordinate ideas hierarchically in a logical order containing the main aspects conforming the topic. 4) Select five key words, representative of the topic discussed, without redundancies or mistakes. 5) Detect possible incongruities in the text. Regarding this last point, a notably inconsistent sentence was introduced on purpose in 31% of the tests given. The discrepancy was included right after the last two lines in the second paragraph, reading:

"...Inside it, the organs are developed in a large space, which allows a better process". This statement related to the concept of *celom* was placed after the definition of *acelomates* (organisms without celom).

The material was distributed to 50% of the total student population (95) and the data presented corresponds to 20 students who volunteered to answer the test. Those who didn't take it, argued that the analysis of the excerpt of the text took too much of their time. The test was given after the last partial test on the subject, when there is supposed to be a greater interaction between the students and their textbook. The test results were tabulated according to the criteria established for solving the instructions.

Results and discussion

The results obtained from the analysis of the text excerpt performed by 20 students (21.05% of the total population), are shown in Tables I, II and III.

Most of the students included a title for the excerpt; however, only one fulfilled all three requirements: relevant, complete and representative. The remainder gave it relevant titles and approximately half of them were complete. Four students created incorrect titles, two of them used elements from the secondary idea as part of the title and the others incorporated incongruities, showing an incorrect use of the terms and so, of the concepts. For instance, including metazoans and platyhelminths; or referring only to invertebrates, or alluding exclusively to the function of the intracavitary liquid (see Table I).

Table I. Number and percentage of students who gave it a title

With a title	Without a title			
2 (10%)	**Incorrect**	**Relevant**		
	4 (20%)	**Incomplete**	**Complete**	
		7 (35%)	**Representative**	**Non representative**
			1 (5%)	6 (30%)

In the text there was one main or central idea and numerous subordinate clauses (see Table II). Within the latter, the 2nd, 3rd, 4th and 5th hierarchical order were computed, according to their relevance in the text. As can be seen, 12 students recognized the main idea in the text, but 8 of them did so inadequately, since in some cases, they added to the central idea elements of the 2nd order clause, whereas others broke down the main idea. Four students identified it correctly and a smaller number recognized the other clauses in a complete way according to their corresponding hierarchical order. The 4th order clause (b) was identified by several students, albeit incompletely. To that effect, it should be said that the ability to organize the ideas in a hierarchical order is what allows the extraction of the essential in the text to simplify its commitment to memory (De Zubiría, 1997).

Table II. Number and percentage in parentheses of students who identified the main idea and the subordinate ones

Level	Main idea 1st order	Clauses				
		2nd order	3rd order	4th order (a)*	4th order (b)*	5th order
Incomplete	8 (40%)	1(5%)	1 (5%)	-----	5 (25%)	1 (5%)
Complete	5 (25%)	3 (15%)	3 (15%)	2 (10%)	1 (5%)	2 (10%)
Not Identified	7 (35%)	16 (80%)	16 (80%)	18 (90%)	14 (70%)	17 (85%)

* 4th order a and b: Clauses with the same degree but found in different paragraphs.

According to pre-established criteria, fifteen students (75%) elaborated a summary, in which three (15%) met the qualities: coherent, complete and with the appropriate length. Many wrote it using the copy-subtraction technique. Although most summaries did not surpass the space available, some showed a lack of coherence (5-25%) and others included conceptual errors (2-10%). Among the students who didn't write it, two (10%) elaborated instead, a conceptual diagram through term association. The students who proceeded correctly applied cognitive and meta-cognitive abilities to understand what they had read. These became evident through the unity, coherence and overall sense of the summary, where they had to arrange the ideas hierarchically based on the main clause, for its comprehension (Dijk, 1989).

According to the instructions, 14 students chose five key words and most incorporated representative, non-redundant terms, without conceptual errors (70%) (see Table III). Between those 14, three (15%) introduced non-representative, redundant and conceptually imprecise words (10%). Those who used less than five words did so adequately. From the total of tests performed, 11 included a clearly discrepant clause. Only one student was able to identify it (5%), whereas for the rest it went by unnoticed. Among the latter, two students pointed out correct clauses as inconsistent, although one of the tests had no incongruities.

Table III. Number of students who solved the instruction of key words and detected the incongruous clause

	Number of students / Number of words	Representative words		Redundant words		Conceptual error		Incongruity n = 11	
		Yes	No	Yes	No	Yes	No	Recognize	Don't recognize
	1/2								
	3/3								
	2/4								
	14/5								
Total	20	17	3	3	17	2	18	1	9
%		85	15	15	85	10	90		2*

n = 11: Number of tests with incongruity.
 * Number of students who pointed out a correct idea as incongruous.

The processing of this information should have been easy for the students, since most of the concepts had been developed in a subject from the 4th four-month term and recovered, to be integrated with the new knowledge in the 5th four-month term subject, especially at a time when they were concluding the evaluations of that subject. Among the students who solved the instructions, there were those who showed difficulties in organizing the ideas hierarchically and identifying the main idea from the secondary ones. Several couldn't find a complete title representative of the topic discussed. It was difficult for them to clearly identify the fundamental idea of the subject and its most relevant elements. They didn't resort to their previous knowledge to recognize the text structure and reflect it in the summary, and many were incapable of identifying the discrepancy. Everything indicates that they evaluate and regulate their reader comprehension in a deficient manner.

The goal sought while reading determines what abilities and abilities must be brought into play while reading. A text isn't read in the same manner to pass the time, or to identify the main ideas, to find the best title, to draw conclusions or to make a critical judgment of it. A good reader employs mental processes that allow him or her to identify the text structure and update his or her schemes (Contreras & Covarrubias, 1999).

Comprehensive reading of a scientific text as the one analyzed here, even though there isn't a good adaptation of its English version, implies that the student must recall what he or she already knows to update and broaden the conceptual network. When prior ideas on a given topic aren't evoked, there are no schemes of thought available to activate a specific knowledge and so, comprehension will be very difficult, or even impossible (Quintana, 2000). Our results show the most significant difficulties students have in text comprehension. These are related to drawbacks in the way of dealing with the information provided in the text, with failure to recall previous knowledge and the lack of self-regulation of the comprehension process.

The students who fragment the information they get from reading will have a hard time choosing from their previous knowledge what is most relevant to allow them to integrate the new information. Later, it will be impossible for them to spot the origin of their difficulties, and in the end, they won't detect the signs of a lack of comprehension. Consequently, they will be unable to analyze the information in the text and activate the significant knowledge (Benito, 2000).

Conclusions

This study allows for a general view of the aptitude and deficiencies in comprehensive reading in the group of 3rd year students in the elementary levelof the Biological Science major at the UNC, which is integrated by few proficient readers and others that still appear to be unskilled. The reader with a specific formal education who reads scientific texts should be capable of identifying the

author's communicative intent, as well as recognizing and relating the clauses in different hierarchical levels. He or she must also separate from the group of clauses the main idea containing the topic from those whose job it is to present, expand on, support, or exemplify it. In this way, he or she can enrich his or her cognitive schemes and increase the number of inferences, which will simplify future reading and improve the inter-textual proficiency (De Zubiría, 1997; Areiza & Henao, 1998, 1999; Contreras & Covarrubias, 1999).

The results indicate that some students haven't yet reached this level of comprehensive reading, defined by De Zubiría (1997) as tertiary de-codification elementary reading. Such a situation should urge university professors, who take it for granted that their students "should understand" the specific subject matter in the scientific texts, to reflect on the problem.

Comprehension isn't an all-or-nothing process; students can partially understand, in different degrees, or understand fully. Furthermore, they can be making certain types of mistakes repeatedly (Contreras & Covarrubias, 1999).

The loss of the reading habit in young people can be linked to a number of causes among which lack of interest, lack of motivation, socio-economic deterioration, changes in values and technological advances, can be found.

Recently in Argentina, the inability for comprehensive reading in students in the elementary level, according to the United Nations Educational, Scientific and Cultural Organization (UNESCO) information, has bred concern ("La brecha social", 2003). Specialists relate this problem to the scarce investments destined to education in all of Latin America.

On another level, technologies such as books, cinemas, television, videos and computers, have become incorporated in a natural and progressive way to the learning process (González Pérez, 2001). Nevertheless, the impact computers have had on our society has given way to very contrasting and uneven opinions. Thus, to some pedagogues, computers are a tool that doesn't collaborate as is expected with the integral development of linguistic abilities (Greyback, 1999).

The problem could be associated with the educational context and the aptitudes of those who plan the goals and activities when the time comes to use computers. Although it has been accepted that the adequate use of the new information and communications technologies (NICT) allows to put pedagogic principles into practice where the subject is the protagonist in the building of knowledge (Waldegg, 2002), in some middle level education schools in Argentina, computers have a reduced incidence in the students' didactic development and daily work. Most of the activities are limited to the use of the word processor and the search for information by electronic means. This hardly favors the development of strategies that can help overcome the concept comprehension problems (Martínez, *et al.*, 2001). On the other hand, outside the school environment, many young people spend a great deal of their time in stores providing Internet services (cybercafes,

Internet cafes) performing diverse activities with more attractive and participative options, (online games, chatting, interaction with the media), that don't exactly promote cognitive aptitudes of a higher level.

Currently, the development of networks with electronic technical support (Web), have given way to a more interactive stage for the teaching-learning process. However, for the Latin American countries, the transition towards digital information and knowledge implies financial investments that are far from equaling those of industrialized countries (González Pérez, 2001).

In the search to awaken and motivate students through the use of strategies that are on a level with circumstances, we have developed and evaluated a hyper-textual resource on CD regarding specific topics from the 4th four-month term subject in the above-mentioned Biological Science major. This was used by students as a supplement of other didactic materials and had the goal of promoting a more participative and active teaching and learning process. This resource contained a group of real and recreated color images together with explicative text boxes and linked to conceptual maps and comparative charts that organize and complement the information. Some of the evaluation results indicated that when the readers don't integrate what they already know with the new concepts, they become poorly skilled in processing the information by not controlling or evaluating their cognitive processes. This suggests that the difficulties in comprehensive reading are present beyond the resource used (Carranza & Celaya, 2003).

The cognitive configuration of an individual is built with his or her own conceptual structure and with the semantic information he or she gets from the world and the context. All of this integrates his or her previous knowledge, which is a support for acquiring new knowledge (Areiza & Henao, 1999; Woolfolk, 1996). Reading texts, especially scientific, is a key point for recovering the knowledge acquired and making use of the concepts that activate memory, the ability to reason, to make sense of things and the ability to evaluate the cognitive processes developed, that is, to display the cognitive and meta-cognitive abilities.

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