

Making Sense of Photographs in Science Textbooks and Lectures

By

Lilian Pozzer-Ardenghi

Licentiate, Universidade Federal de Santa Maria, Brazil, 2000

A Thesis submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF ARTS

in the Department of Curriculum and Instruction

We accept this thesis as conforming
to the required standard

[REDACTED]
Dr. W.-M. Roth, Supervisor (Department of Curriculum & Instruction)

[REDACTED]
Dr. R. Anthony, Departmental Member (Department of Curriculum & Instruction)

[REDACTED]
Dr. G. M. Bowen, Departmental Member (Department of Curriculum & Instruction)

[REDACTED]
Dr. G. Van Gyn, External Examiner (School of Physical Education)

©Lilian Pozzer-Ardenghi, 2003

University of Victoria


All rights reserved. This thesis may not be reproduced in whole or in part, by photocopy
or other means, without the permission of the author.


Supervisor: Dr. Wolff-Michael Roth


ABSTRACT

Photographs constitute a major aspect of high school biology textbooks, which dominate current classroom approaches to teaching and learning. However, little is known about how students make sense of and learn from photographs; even less is known about the different resources available for making sense of photographs both in textbooks and in lecture situations. Constituted of three interrelated studies, this thesis is concerned with the use of photographs as pedagogical resources to teach scientific concepts. In the first study I investigate the semiotic resources for interpreting photographs that high school biology textbooks make available to their readers. In the second study, I analyze gestures and body position as semiotic resources made available by lecturers who used photographs as part of their presentations. In my third study I investigate how students make sense of photographs associated with written texts. The results of my study have implications for textbooks' authors and readers, and for teachers and lecturers.

Examiners:


Dr. W.-M. Roth, Supervisor (Department of Curriculum & Instruction)


Dr. R. Anthony, Departmental Member (Department of Curriculum & Instruction)


Dr. G. M. Bowen, Departmental Member (Department of Curriculum & Instruction)



Dr. G. Van Gyn, External Examiner (School of Physical Education)

TABLE OF CONTENTS

Title	i
Abstract	ii
Table of Contents	iii
List of Tables	iv
List of Figures	v
Acknowledgments	vii
Dedication	viii
Chapter I: Introduction	1
Chapter II: Prevalence, Function and Structure of Photographs in High School Biology Textbooks	13
Chapter III: Photographs in Lectures: Gesture and Body Position as Meaning- Making Resources	57
Chapter IV: Making Sense of Photographs	98
Chapter V: Conclusions and Implications	145
Bibliography	165

LIST OF TABLES

Table in Chapter II

Table 2.1: Categories of Photographs, their descriptions and frequencies 24

Table in Chapter III

Table 3.1: Functions of gesture/body positions in the presence of photographs and
speech 75

LIST OF FIGURES

Figures in Chapter II

Figure 2.1	16
Figure 2.2	20
Figure 2.3	26
Figure 2.4	28
Figure 2.5	30
Figure 2.6	33
Figure 2.7	35
Figure 2.8	36
Figure 2.9	38
Figure 2.10	40
Figure 2.11	44
Figure 2.12	45
Figure 2.13	47
Figure 2.14	48
Figure 2.15	49
Figure 2.16	50
Figure 2.17	51

Figures in Chapter III

Figure 3.1	63
Figure 3.2	77
Figure 3.3	78

	vi
Figure 3.4	79
Figure 3.5	82
Figure 3.6	84
Figure 3.7	86
Figure 3.8	88
Figure 3.9	89
Figure 3.10	91
Figures in Chapter IV	
Figure 4.1	106
Figure 4.2	107
Figure 4.3	108
Figure 4.4	109

ACKNOWLEDGMENTS

A Deus, Muito Obrigada!

A minhas queridas irmãs, Fernanda e Caren, e a meu querido irmão, Henrique, eu agradeço todo o amor e o apoio material, moral, emocional e espiritual, que certamente contribuíram grandemente para o término desta tese.

À minha querida tia e mestre, Dr. Maryangela Leivas Amorim, agradeço pelo exemplo dado e que será sempre seguido. Agradeço também por ter me apresentado ao mundo da Educação, ao qual agora orgulhosamente pertença.

Ao professor Dr. Eduardo Adolfo Terrazzan, agradeço todo o incentivo e apoio, fundamentais para que eu chegasse onde cheguei.

A todos os amigos e familiares, eu agradeço o apoio incondicional.

To my parents, Fernando and Sonia,
and to my husband, Diego.

Chapter I

Introduction

The research presented in this thesis was designed to address various aspects of the use of photographs as pedagogical resources in teaching scientific concepts. Specifically, this thesis is about the semiotic (meaning-making) resources available for interpreting photographs when they are used in textbooks or lectures. Three studies constitute this thesis. The first investigated the semiotic (meaning-making) resources that textbooks provide for understanding the photographs that are featured; the second investigated the semiotic resources that lecturers provided to their audiences while presenting photographs; and the third study investigated the semiotic resources actually used by 12 high school students when they were presented with photographs and associated texts from widely used biology textbooks. These studies represent three different and yet interrelated aspects of my research program, and they were concerned with different aspects of the use and interpretation of photographs in school science related contexts.

In this chapter I will briefly present my personal motivation for engaging in this research; I provide definitions of important terms used throughout this thesis; and I briefly outline the three studies that constitute this thesis.

1.1. Personal Motivation

The research I developed over the last two years, and the results of which constitute this M.A. thesis, emerges from an episode I witnessed during my teacher training, when I was teaching at a public high school in Santa Maria, RS, Brazil.

During my teacher training program, as part of my Biological Sciences undergraduate course at the Federal University of Santa Maria, I was supposed not only to experience teaching in the classroom, but also to participate in all activities that go on

at the school. Therefore, I participated in many meetings, conferences, even barbecues. But the most interesting event out of the school was the afternoon break, when all the teachers meet for 20 minutes in the staff room, between the first three classes they already had behind them and the next two classes that they still would be teaching during their regular school day. During afternoon breaks, teachers often drink tea and revise their classroom activities; but mostly, they talk. They talk about classes, students, administration, other teachers, new books, new approaches, and also many other subjects not strictly related to the school, such as culinary delights, husbands and wives, children, politics, soap operas, and so on.

My classmates and I were always together during these afternoon breaks, usually sitting very quite in a corner, attentively listening to everyone. It was very interesting to listen to teachers' conversations, because I was always learning something in the process; and as long as we had a perfect excuse to do so, we made the best we could of this opportunity. It was one of these conversations I witnessed that was going to influence my later work as an M.A. student at the University of Victoria.

I remember when one of the biology teachers came into the staff room and called together all the other biology teachers—there were about six biology teachers in the room at the time—because she wanted to show them a “marvelous” biology textbook she had recently bought. They all gathered around her and started talking about the new textbook. One might have expected the teachers to discuss the contents of the textbook, the way in which it presented these contents, and so on. However, I was utterly surprised when all I could hear was the teachers talking about the pictures in the textbook. Seven biology teachers, with years and years of experience teaching at high school, were together

discussing a new textbook, which they believed was marvelous because of its illustrations, and therefore should be adopted for the next school year.

From this moment on, I have been asking myself, “What is so compelling about an illustration, especially a photograph, that makes experienced teachers choose a textbook solely based on its illustrations?” Are the photographs really useful for teaching biological concepts, so much so that textbooks full of illustrations are considered better than other textbooks with fewer illustrations? How do photographs help to understand a scientific concept? How are photographs employed in textbooks and lectures, and most importantly, how do students interpret these photographs?

In this thesis, I will present three distinct yet interrelated studies that deal with these and other questions. These three studies were presented at international conferences, and were or will be submitted for publication in renowned educational journals.

1.2. Important Definitions

Throughout the three studies that constitute this thesis, various terms are used which bear crucial importance for the understanding of my research work. In this section I provide a brief explanation of important terms employed throughout my thesis, as this may be useful for the reading of the following chapters.

1.2.1. Inscriptions

Inscriptions are visual representations that are materially embodied in some medium, such as paper or computer monitors. Graphs, tables, lists, photographs, diagrams, spreadsheets, and equations are characteristically classified as inscriptions.

Although texts are technically also inscriptions, the pertinent literature does not include it but uses the term only for the visuals (Latour, 1987).

Inscriptions, as opposed to mental representations, are publicly and directly available so that they are primarily social objects. Knowledgeability with respect of inscriptions is indicated by the degree to which individuals participate in purposive, authentic activities where these representations are a central aspect (Roth & McGinn, 1998). Inscriptions present many intrinsic characteristics, such as mobility and immutability, and capacity to merge with geometry. Inscriptions can easily be incorporated into different contexts and they are easily rescaled to produce larger or smaller images without changing their internal relations. Several inscriptions can be combined and superimposed; and they can be reproduced at low economic, cognitive, and temporal cost. Most importantly, an inscription does not have meaning in and of itself; rather, its meaning arises in the context of its use and in the context of other inscriptions and sign forms (e.g., language and gestures).

The term inscription largely has been used in science and technology studies, as an increasing number of studies document the important role of representation practices in science (e.g., Knorr-Cetina & Amann, 1990; Latour, 1999; Lynch & Woolgar, 1990). Inscriptions that stand for natural phenomenon usually appear first in scientific laboratories and field research sites, and—after having been cleaned, superposed, and transformed—are later used in scientific publications. The more information an inscription summarizes, the more it becomes complex, resistant to deconstruction, and powerful. However, the amount of information that can be summarized in an inscription also determines its abstractness. That is, as more information is collated together into one

and the same inscription, the more contextual detail is simultaneously dropped (Latour, 1987).

Photographs are one type of inscription. Although they are of lesser importance in the scientific literature, such as science research journals, they constituted the predominant form of inscription in North American high school biology textbooks (Roth, Bowen, & McGinn, 1999).

1.2.2. Semiotic Resources and Semiotic Analysis

Semiotics or Semiology is the study of the function of signs and symbols in human communication, concerning both language and communication by various nonlinguistic means (Hutchinson, 1992). In this thesis, I refer to semiotic resources as those resources that are available to the reader of a textbook, and to the audience of a lecture to make meaning. That is, semiotic resources are meaning-making resources, anything that helps readers or audiences to make sense of the texts (written text or speech), and photographs when scientific concepts are being introduced.

Similarly, semiotic analysis refers to the analysis of the semiotic resources available in different contexts where scientific concepts are taught. In the three studies that constitute this thesis, the semiotic analysis in which I engaged was also intertwined with notions of other methodological frames, such as, Interaction Analysis (Jordan & Henderson, 1995), and Forth Generation Evaluation (Guba & Lincoln, 1989), that present procedures for assessing the quality of qualitative research.

1.2.3. Interaction Analysis

Interaction Analysis is an interdisciplinary method for empirically investigating the interaction of human beings with each other (e.g., talk, nonverbal communication), and with objects in their environment (e.g., the use of artifacts and technologies). Its roots lie in ethnography (especially participant observation), sociolinguistics, ethnomethodology, conversation analysis, kinesics, proxemics and ethology (Jordan & Henderson, 1995).

Interaction Analysis considers knowing and learning to be distributed across the social and material environment; learning is therefore also an ongoing social process, and the evidence of the occurrence of learning lies in the ways in which people collaboratively do learning and recognize learning as having occurred (Garfinkel, 1967). In conducting Interaction Analysis, our expertise as competent members of communities of practice partly constitute the analytic work. That is, even when I analyze unfamiliar data, I draw on my existing presuppositions of how the world works to make sense of these data. The analytic categories that emerge from an interaction analytic work are not predetermined, that is, categories emerge as the analysts' understanding of the orderliness of the interaction evolves and becomes deeper, as participants on the videotape make this orderliness visible to each other.

Interaction Analysis is a reflexive form of analysis, because researchers not only analyze interactions but do so collaboratively, that is, by interacting themselves to make sense in a collective manner. To get me started, and to ascertain that my categories meet the highest scholarly standards, I periodically engaged in collective analysis together with my supervisor Dr. Wolff-Michael Roth. Collective analysis is a powerful means of dealing with and in fact neutralizing preconceived notions on the part of individual

researchers. The collaborative viewing of data minimizes the tendency researchers have to see what they are conditioned to see or even what they want to see; in fact, during the interactive analysis, we are confronted with different ways of seeing and therefore with our own interpretive horizons. Inferences about what is happening on the videotape pertaining to individuals' thoughts and intentions are discouraged in Interaction Analysis working groups, unless there is evidence of these activities on the videotape which can be referred back to. Therefore, interaction-analytic statements about general patterns are generated through empirical observations, as an inductive process.

1.2.4. Goodness Criteria for Judging the Quality of Research

In chapter four of Fourth Generation Evaluation (Guba & Lincoln, 1989), the authors present three different approaches to assess the quality of goodness of constructivist enquiries. They refer to the so-called *parallel* criteria, which have their roots in positivist assumptions; they consider *the nature of the hermeneutic process itself* as another criteria; and they refer to the *authenticity* criteria, which is a new set of non-foundational criteria, embedded in the basic belief system of constructivism itself. To the extent that these criteria were applicable to any of the three studies conducted for this thesis, I have implemented them.

The *parallel* or *trustworthiness* criteria include *credibility*, *transferability*, *dependability*, and *confirmability*. The *credibility* criterion focuses on the match between the constructed realities of respondents and the realities that are represented by the enquirer and attributed to the respondents. The techniques involved in this criterion are (1) *prolonged engagement*, which refers to substantial involvement at the site of the inquiry; (2) *persistent observation*, which aims to add depth to the scope which prolonged

engagement affords; (3) *peer debriefing*, which is defined as the process of engaging, with a disinterested peer, in extended and extensive discussions of one's findings; (4) *negative case analysis*, which provides confidence that the inquirer tried and rejected all rival hypotheses save the appropriate ones; (5) *progressive subjectivity*, defined as the process of monitoring the enquirer's own developing construction; and (6) *member checking*, which is a continuous process, formal or informal, that happens both during the data collection and analysis stage whereby participants are asked to verify the results of the qualitative analyses.

Following the *transferability* criterion, the researcher provides as complete a data base as possible to facilitate transferability judgments on the part of others who may wish to apply the study to their own situation. The *dependability* criterion is concerned with the stability of the data over time. Methodological changes and shifts in constructions do not constitute threats to dependability when they are both tracked and trackable, that is, when they are publicly inspectable. The technique for documenting the logic of process and method decisions is the *dependability audit*.

Confirmability is concerned with assuring that data, interpretations and outcomes of inquires have their roots apart from the inquirer and therefore, are not figments of the inquirer's imagination. The usual technique for confirming the data and interpretations of an inquiry is the *confirmability audit*. *Dependability* and *confirmability audits* should be carried on together, constituting an *audit trail*.

The hermeneutic process as its own quality control constitutes another approach for assessing the goodness of research. In this case, data inputs are analyzed immediately on receipt, and are incorporated into the emergent joint, collaborative reconstruction that

emerges as the process continues. The immediate and continuing interplay of information minimizes the possibility of noncredible outcomes. Finally, the *authenticity* criteria includes (1) *fairness*, which refers to the extent to which different constructions and their underlying value structures are solicited and honored within the evaluation process; (2) *ontological authenticity*, which represents the extent to which individual respondents' constructions are improved, as they acquired more information and become more sophisticated in its use; (3) *educative authenticity*, which considers the extent to which individual respondents' understandings of and appreciation for the constructions of others are enhanced; (4) *catalytic authenticity*, which is defined as the extent to which action is stimulated and facilitated by the evaluation process; and (5) *tactical authenticity*, which refers to the degree to which participants are empowered to act.

1.3. Outline of the Three Studies

The three studies present in this thesis deal with the topic of photographs and its use as pedagogical tools in teaching scientific concepts. The first study, "Prevalence, Function and Structure of Photographs in High School Biology Textbooks," presents an analysis of the semiotic resources that textbooks make available to their readers for interpreting photographs and for connecting them to their associated texts. This study reports the many problems related to the interpretation of photographs in textbooks, as for example, absence of captions, misplaced indexical references, presence of excessive informational details in the photographs, and so on. I provide a categorization of the different types of photographs present in the textbooks analyzed and discuss their potential as pedagogical resources. I also present in this study an extensive analysis of the structural elements associated with the use of photographs in textbooks and their

importance as meaning-making resources to interpret photographs. Suggestions are included at the end of this study concerning the proper use of photographs in textbooks to assure that these inscriptions achieve their full potential as pedagogical resources in the teaching of scientific concepts.

In “Photographs in Lectures: Gesture and Body Orientation as Meaning-Making Resources,” I investigated the semiotic resources made available in lecture situations when photographs are being used. My database consisted of three different lecture settings, where speakers were talking about scientific concepts while making use of photographs projected in different ways: standing next to the projected image in a fairly well-lit room, lecturing in darkened hall, and lecturing by using an overhead projector. The gestures and body orientations used over and about the photographs during lecturers’ speeches were categorized and analyzed accordingly to their semiotic functions. Some important parallels are drawn between the pedagogical potential of photographs in lectures and in textbooks. I suggest ways in which the use of photographs as pedagogical resources in teaching a scientific concept may be improved, as these inscriptions are used in lectures situations.

The third study in this thesis is concerned with students’ work of interpretation of photographs as they read textbooks. “Making Sense of Photographs” addresses yet another aspect of the use of photographs as pedagogical resources in the teaching of scientific concepts. In this study, 12 students from different grade levels were interviewed. The interviews were videotaped and a thorough analysis of students’ interpretation of photographs and texts was then pursued. From my analysis, many aspects previously made salient in my first study came to the foreground again,

confirming and reinforcing the results of both studies particularly with respect to the semiotic resources available in textbooks for understanding photographs and connecting them with texts.

These three studies, although representing different stages of my research endeavor during my MA program, are interrelated and, consequently, they collectively have implications for science education in general, and textbook authors and teachers in particular.

Chapter II

Prevalence, Function, and Structure of Photographs in High School Biology Textbooks

Abstract

Photographs are a major component of high school science textbooks, which dominate classroom approaches to teaching and learning. It is surprising then that the function of photographs and their relation to captions and texts have not been the topic of analysis. The purpose of this study was to investigate the prevalence, function, and structure of photographs in high school science textbooks. The motivating research question was, “What can students learn from textbooks when they study photographs?” To answer this and several subordinate questions, I selected and analyzed four Brazilian biology textbooks. I focused on the use of photographs and the relation between them, various types of texts, and the subject matter presented. The analysis reveals that the structural elements of text, caption, and photographs and the relations between them differ across the textbooks and at times even within the same book. This, of course, will influence readers’ interpretations of the photographs and changing their role in the text. The results of this study have implications for textbooks authors and textbook readers. I suggest that future studies may focus on students’ and teachers’ interpretation of photographs in real time.

2.1. Introduction

High school biology textbooks fail to make big ideas comprehensible and meaningful to students: “At their best, the textbooks are a collection of missed opportunities” (Ellen Roseman, cited in AAAS, 2000, §7). Another AAAS study showed that the instruction presented by textbooks is inadequate (Ralof, 2001). What exactly is wrong with textbooks? To address this question, this study concerns one aspect of high school biology textbooks, that is, photographs and their associated texts and the resources they make available to students for understanding and making meaning of scientific ideas.

Photographs constitute a major aspect of high school science texts; a recent study showed that there are about 17 photographs on every 20 pages of high school biology textbooks (Roth, Bowen, & McGinn, 1999). It is surprising then that a photograph (like a word) on its own does not mean anything (Bowen & Roth, 2002; Wittgenstein, 1994/58); it is only through recurrent use in similar situations that the relation of a word to other words, a photograph to other photographs and words are established. For example, one might ask, “What is the content of the photograph in Figure 2.1?”, which was taken from a Brazilian high school biology textbook.¹ “What is its meaning?” There are some cows in the foreground, two trees and a fence further back. Then there is a field or meadow before an assembly of trees, which may be seen as a “forest.” So what does it mean? To find an answer, I have to seek recourse to the text from which I culled the photograph. The caption to the photograph talks about there being distinct biomes (“The dividing line

¹ All photographs have been scanned, with permission from the publisher, in black and white from the textbooks. I translated the original Portuguese captions into English.

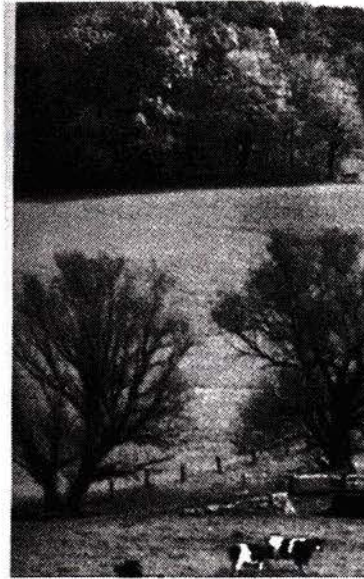


Fig. 538. Two distinct biomes border on each other: the forest and the savanna. The latter is a variety of field. The dividing line between both biomes is a band with higher density of vegetation and what identifies the **ecotone**.

Figure 2.1. Example of a photograph and caption from a Brazilian high school biology textbook in the context of teaching the concept “ecotone.”

is a band with major vegetation that defines an ecotone”).² Knowing this, I can now return to the photograph and attempt to discover distinctness that would delimit the different biomes that we are to find. Further reading of the caption then tells me something about changes to greater density. The caption also talks about forest and savanna, the latter being a kind of field.

Once I find these descriptions, my gaze separates forest and field, disregards the trees in the foreground, and isolates changes in plant density. What the text has done,

² All texts have been translated from Portuguese to English by me. An ecotone is defined as an ecological community of mixed vegetation created by the overlap of adjoining communities (Kieft, White, Loftin, Aguilar, Craig, & Skaar, 1998); it is usually a belt rather than an abrupt line. For example, the floodplains of the Amazon River are sometimes interpreted as ecotones between upland and rivers, and sometimes they

therefore, is not just describe what there is in the image—if it was only a description of something self-evident, it would not have been necessary. Rather, the text taught me what to look for and how to parse a rather dense visual field. The text contributes to teaching me how to detect biomes, ecotones, and how to distinguish them—though this particular photograph makes the concept of ecotone appear in a simplistic way as a clearly identifiable boundary. At the same time, the text in itself lacked something that the image provides. Here, the figure *authenticates* what the text is about, the existence of biomes and ecotones, and the borders that exist between biomes. In sum, the texts that are copresent with the photograph provide the pedagogy for reading the photographic image, allowing a small rather than a potentially infinite number of interpretations to be viable.³

“What can students learn from textbooks when they in fact begin to study photographs?” The question is salient particularly in the context of the present photograph because of the difficulties of making distinctions between forest and savanna experienced even by scientists (Latour, 1999). Thus, Latour documents in great detail an expedition in which Brazilian and French scientists attempted to decide whether the forest was taking over the savanna or whether the savanna was taking over the forest. A major problem to be resolved by the scientists he studied was just where to locate the boundary between forest and savanna; another sociological study of ecologists also showed the tremendous collaborative work that went into deciding what constitutes the boundary between forest and bush (Roth & Bowen, 1999b). Finally, Law and Lynch (1990) documented similar difficulties experienced by amateur birdwatchers as they

are viewed as specific ecosystems. But there is still a lot of controversy over the ecotone concept, in part because boundaries cannot be easily delineated (Fraser & Williams, 1998).

³ “Pedagogy of photographs” tells us what and how photographs and the associated texts work and work together to teach a science concept.

attempted to identify birds even though they had the photographs of their bird field guide directly in front of them. In practice, therefore, making a distinction between forest and savanna appears much more difficult than the high school textbook leads us to believe. As a science educator, I therefore question, what can and do photographs achieve when they are used in high school textbooks? What purpose do photographs serve if they cannot guarantee that students identify their equivalent in the natural world—after all, are science students not supposed to understand and be able to explain the world around them?

High school science is dominated by textbooks-oriented approaches to teaching and learning. However, little research has been done in science education research regarding the quality of curriculum materials, particularly textbooks. Therefore, “[f]ar more research should be done to provide consumers (e.g., science teachers and principals) with better information about curriculum materials” (Good, 1993, p. 619). The purpose of this study is to analyze the use of photographs in high school biology textbooks, what these photographs provide for meaning-making processes, and the relation between them and the subject matter presented in the text. This study was motivated by the goal to understand the prevalence, function, and structure of photographs in biology textbooks, that is, to better understand the pedagogy of photographs in high school science. The textbooks chosen as data sources are widely used in Brazil.

2.2. Background

An increasing number of studies document the important role of representation practices in science (e.g., Knorr-Cetina & Amann, 1990; Latour, 1999; Lynch & Woolgar, 1990). In sociological studies of science, the notion of “inscription” is used

instead of representation for all socially shared representations other than text independent of their medium (Latour 1987). Inscriptions that stand for natural phenomena usually appear first in scientific laboratories and field research sites, and—after having been cleaned, superposed, transformed—are later used in scientific publications. The more information an inscription summarizes, the more it becomes complex, resistant to deconstruction, and powerful. However, the amount of information that can be summarized in an inscription also determines its abstractness. That is, the more information that is collated together into one and the same inscription, the more contextual detail is being dropped (Latour, 1987). Thus, a photograph of a rose represents one particular rose, whereas a drawing of a rose may stand for roses more generally (Figure 2.2). This claim is supported by research that showed that it was easier to classify birds using a field guide with drawings, which represent birds more generally, than using a field guide with photographs, which display birds more specifically and with considerable background detail (Law & Lynch, 1990).

The elimination of gratuitous detail is part of the move from the particularity of one observation to the generality of a scientific claim (Myers, 1990). Therefore, photographs are placed at one end of this set of categories, presenting the background as a space continuous with our own lived experience, and, then, full of gratuitous detail. All this detail may not carry relevant information; however, it does have a function, making the photograph seem to be an extension of nature into the pages of the book, even though the effect of realism does not depend on the complete reproduction of the world. The photographs obtain their powerful role as representations of the real world through the reader's work of interpretation, the viewer's perception of the narrative and perceptual

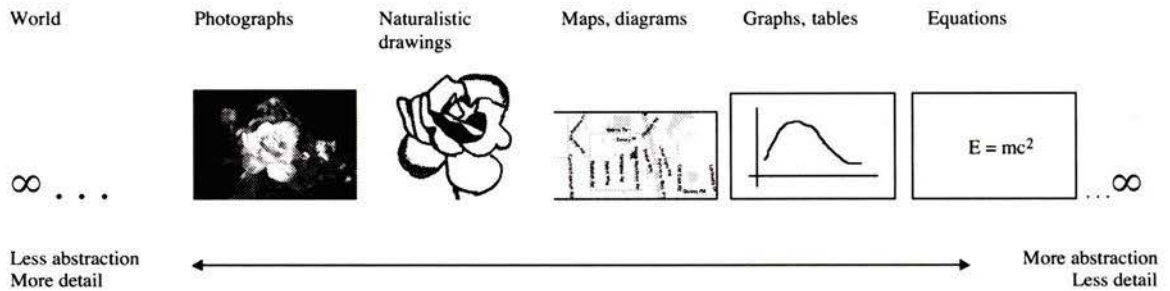


Figure 2.2. Representations lie along a continuum depending on the amount of contextual detail that they carry in the background of the central object proper.

order of the document (Bjelic, 1992; Morrison, 1989).

Whereas in professional science there is a preference for inscriptions to the right side of Figure 2.2, high school science textbooks predominantly use photographs and naturalistic drawings (Roth *et al.*, 1999). This is perhaps correlated with the fact that photographic and pictorial inscriptions are more likely to have an impact on individuals outside of science than graphs or equations that are often incomprehensible to students and other lay people (Myers, 1990). In the educational literature, there are a number of reports that focus on student's use of representations together with textual information. However, despite the large range of possible instructional functions of inscriptions, research provides little evidence that inscriptions live up to their potential in print (e.g., Schnotz, Picard, & Hron, 1993) and computer media (Lowe, 1999).

Despite the centrality of representation practices in science and despite the many open questions as to the role of inscriptions in instruction, relatively little work has been done in science education from either sociological or psychological perspectives. Consequently, a deep understanding and sound theory of cognition typically do not inform the use of inscriptions. Traditionally, textbooks have been important resources in

students' learning because most science classes are oriented toward these resources.

However, teachers and students appear to focus almost exclusively on text, leaving aside inscriptions that could assist them in learning and understanding. How inscriptions are deployed in textbooks plays an important role in the lived experience of students and in their associated appropriation of practices in the course of schooling. A better understanding of how various inscriptions interact with text is therefore needed.

Most students are familiar with photographs in general; however, appropriate instructions for how to read and analyze photographs are currently not provided to them. Outside science education, a small number of studies considered the role of photographs in communication (Bastide, 1990; Livingston, 1995). Such studies show that photographs come with apparent self-evidence. Because of the similitude with the objects represented, photographs are taken as *prima-facie* evidence, that is, as guarantor of truthful representation (Myers, 1990). Because photographs are automatically produced, and because they are eidetic images of the object portrayed, their constructed nature normally disappears. To understand the effect of photographs in learning, it is necessary to consider not only the way they are produced, but also the way they are received by the reader.

2.3. Study Design

For this interpretive study of photographs, I took as starting point several existing studies concerned with the practices of reading and interpreting scientific representation in general (Bastide, 1990; Lemke, 1998) and photographs and naturalistic drawings in particular (Myers, 1990; Law & Lynch, 1990). I was particularly interested in the semiotic (meaning-making) resources that high school biology textbooks make available

for reading and interpreting photographs, and therefore, in the pedagogy that is associated with photographs in introductory scientific texts.⁴

2.3.1. Selecting the Domain

To study the prevalence, function, and structure of photographs in science textbooks, I selected the four Brazilian high school biology textbooks most frequently adopted in and around Santa Maria, RS (Brazil), where I attended university and received my science teacher training. These textbooks present the entire high school program in biology in one and the same volume; that is, the content that would be taught in different grade levels. I initially surveyed the inscriptions in all chapters of the four books but to make comparisons with an existing North American study (Roth *et al.*, 1999), I conducted detailed analyses of those chapters concerned with ecology. The earlier study showed that the ecology related chapters are similar to other chapters of these same books, and therefore these chapters fairly represent the entire book. To my understanding, the four high school biology textbooks I selected satisfactorily represent high school biology textbooks in general.

2.3.2. Analytic Frame

In this study, I conducted two types of analyses. First, a coarse-grained analysis was conducted pertaining to the prevalence (types and frequencies) of representations in Brazilian high school biology textbooks to test whether the distribution reported by a

⁴ Semiotics is a theory and study of signs and symbols, especially as elements of language or other systems of communication (*The American Heritage® Dictionary of the English Language, Fourth Edition, 2000 by Houghton Mifflin Company*). In this study, I refer to semiotic resources as those resources that are available to the reader to make sense of texts and photographs in high school biology textbooks. Semiotic analysis refers to the analysis of these resources.

study of North American textbooks would be replicable in another culture. Second, a fine-grained approach was developed to analyze the semiotic resources provided by textbooks for reading and interpreting photographs.

I began my study with the category scheme of inscriptions published by Roth *et al.* (1999), a study with which I compare my results. These categories included equations (mathematical and chemical); Cartesian graphs; histogram (bar chart); table (statistics, numerical data, or classification); map; drawing of system (causal model); diagram; (naturalistic) drawing; and photographs (micrographs). I counted inscriptions by “panels” or “plates”; panels or plates are expressed by the use of separate coordinate axes or different letters that distinguish the different parts of a single figure. If there were multiple types of inscriptions within the same plate, I counted the instance as belonging to the dominant category. Thus, I counted an inscription containing a world map, colored to identify different biomes, and including small photographs of each biome as “one” map. To align my classifications, my supervisor and I collaboratively classified inscriptions (seeking out those that were difficult and might lead to disagreement) until we agreed on every instance.

For the detailed analyses of photographs, I randomly opened different textbooks, selecting photographs for a preliminary analysis, only including subsequent samples if they somehow appeared different from all previous ones. I photocopied four photographs (including caption) and the paragraphs from the main text that contained (a) a reference to the photograph or (b) dealt with the same concept that the photograph was said to be an example of. I began by independently studying these examples to (a) develop an analytic frame that I could subsequently use and (b) articulate sample analyses. In this

initial approach, I was guided by the principles of analysis grounded in a semiotics of scientific texts (Bastide, 1990; Lemke, 1998). I subsequently met with my supervisor to discuss my individual analyses to evolve a frame that would work for me in this study. We also discussed all preliminary analyses to find themes that we agreed upon and that could be replicated with other photographs. For inclusion in this article, I ultimately selected photographs that would paradigmatically display the findings that I derived through my analytic work.

Table 2.1

Categories of photographs, their descriptions and frequencies (N = 148)

Categories of Photographs	Description	Frequency Count (%)
Decorative	Photographs without a caption and deictic reference in the text.	8 (5.4)
Illustrative	Photographs with a caption that names the object/phenomenon represented in the photograph. No additional information is available.	52 (35.1)
Explanatory	Photographs with a caption that names the object/phenomenon represented in the photograph, and provides an explanation or classification of this object/phenomenon.	42 (28.4)
Complementary	Photographs with a caption that names the object/phenomenon represented in the photograph, and provides new information about this object/phenomenon, not available in the main text associated to this photograph.	46 (31.1)

Throughout my analyses, I strove to ascertain a high quality of my analyses following the precepts of *Fourth Generation Evaluation* (Guba & Lincoln, 1989). I monitored and recorded my emerging understanding, allowing me to enact prolonged engagement,

sufficient observation, revision of hypotheses through the analysis of negative cases, and progressive subjectivity and to construct an audit trail. For example, I initially identified five different categories of photographs. These included photographs (a) without caption (Decorative Photographs); (b) with captions that name what can be seen (Illustrative Photographs); (c) with captions that name and classify what is represented (Explanatory Photographs); (d) with captions that summarize the content of the main text (Summary Photographs); and (e) with captions that present new information (Complementary Photographs). Toward the end of my in-depth analyses, I abandoned the fourth category after discussing the following assertion with my supervisor:

I have talked about five different categories of photographs in the proposal, but I really think we have only four, because “summary category” is not really exactly a summary, and I just could find three examples of this category, which is actually “forcing” it a little bit.

I revisited the three cases and decided to include these photographs in the fifth category, Complementary photographs, as I believed they are more appropriately classified as a complement to the main text. In Table 2.1, I present brief definitions of each category and the frequency of its occurrence in the corpus.

2.4. Abundance of Inscriptions and Dominance of Photographs

The quantitative data obtained in my analysis shows that the Brazilian textbooks contain even more inscriptions than the North American high school biology textbooks analyzed previously (Roth *et al.*, 1999). However, the mean frequencies of inscriptions for Brazilian and for North American textbooks are similar enough to justify the results of my study being extended to high school biology textbooks in general. The total number of inscriptions in the Brazilian textbooks was found to be

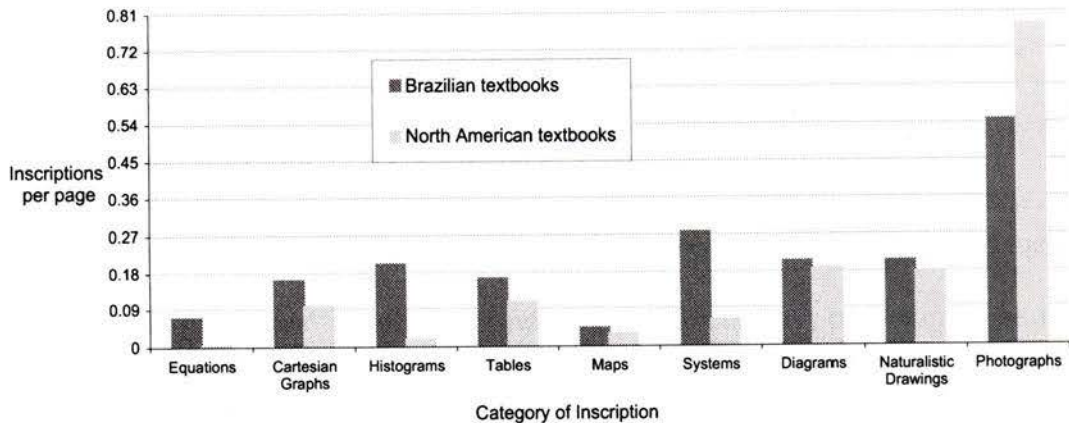


Figure 2.3. Mean frequencies of inscriptions per page in four Brazilian high school biology textbooks and in six North American high school biology textbooks.

1.88 inscriptions per page versus 1.47 inscriptions per page reported for the North American textbooks. Photographs represent the most frequent inscriptions in these books: there are about 0.55 photographs per page in Brazilian textbooks compared to 0.78 in North American textbooks (Figure 2.3). These results show that photographs take an important place in Brazilian textbooks, though with smaller frequency than in the North American study. In comparison, the second most frequent category of inscriptions in the Brazilian analyzed textbooks was about 0.27 per page, about one half the frequency of photographs.

These results show that high school biology textbooks, as scientific texts more generally, heavily draw on inscriptions; in contrast to professional science, though, high school textbooks have a high frequency of photographs and naturalistic drawings. Despite this prevalence, I am not aware of any study that has shown what the semiotic resources of these images and their associated texts are and particularly what the pedagogical functions and the opportunities and constraints for sense making that they present to the novice reader. In the ecology-related chapters of the four textbooks, there were $N = 124$

inscriptions classified as photographs. In the subsequent sections, I present the results that pertain to a semiotic analysis of these photographs.

2.5. Photographs and Texts: Principles of Analysis

I began this article by making the point that a photograph in and of itself means little; it is full of “gratuitous” detail that allows many different ways of looking at and interpreting it. This photographic detail provides a space that is continuous with our own lived world, allowing readers to establish a link with the everyday world that surrounds them. At the same time, the photograph provides few cultural codes (e.g., a line, letter, or recognizable shapes) that could delimit its sense and meaning as intended by the author. To control the range of possible meanings that a photograph can give rise to, authors use captions and embed this photograph/caption combination in still further text (main text) that together constrain the meaning a reader can make. In this section, I propose some principles for the analysis of photographs in school science textbooks.

From a semiotic perspective, the photograph and its caption are two different sign assemblages or two different texts, where text refers more broadly to any entity that can be interpreted (Eco, 1984).⁵ However, caption and photograph are not independent. As captions always appear just below or next to a photograph, the two different and arbitrary sign forms are directly associated with one another. They are said to be about the same thing. Take the photographs and captions in Figure 2.4 that appear in the context of a textbook treatment of “camouflage.” In the last sentence, the caption suggests, “This is a good example of camouflage.”

⁵ Over the past 30 years, the notion of “text” as a more generalized term to refer to anything that can be interpreted has evolved in various social sciences and humanities such as anthropology (Geertz, 1973),



Fig. 577. The European partridge, during the winter, shows white plumage, blending with the snow. At the end of the winter, it starts to change its plumage, and acquires a coloration that blends with the dry vegetation where it lives. This is a good example of **camouflage**.

Figure 2.4. Example of the relations between photographs and its captions.

The caption articulates “winter” and “white plumage,” which calls attention to the color of the plumage during a particular season, winter, which, *if* students are familiar with snow, is easily identified with the left-most image in the figure. (Most of Brazilian students have never seen snow and know it only through the media but not through their lived experience.) Simply by the fact of being articulated, even if it was not named, the white color of the plumage in winter is likely to become salient. Even more so, the presence of three images inherently calls for a comparison of seasons and plumage across all photographs, and thereby makes salient the changes across the three images. That is, the text elaborates and therefore teaches how to read each image and the sequence of images (to understand change). The presence of three images calls for comparisons to identify variant and invariant perceptual properties of what the caption marks as being the same animal.

However, the photographs also (and reflexively) elaborate the caption text in the

sense that they provide evidence for particular statements. The photographs validate what the text states, the whiteness of plumage and the changes the plumage undergoes; the text elaborates how to read the photographs, contributing to its meaning. Here, there are two forms of texts, one verbal one visual, each elaborating the other in their relation to the thing that they are about (e.g., Ricœur, 1991) that is, the idea of camouflage. This “idea” is the real referent of the word and what is to be seen as difference in the collection of photographs. As arbitrary signs, both stand in an open and yet-to-be-elaborated relation to their content, the entity that they are about. The “this,” in “this is a good example of camouflage” can be read as an indexical reference to the content of the previous sentence(s), which describes how to read the photographs, and to the content of the series of photographs, which legitimate the text.

It may be useful here to draw on the notion of intertexts, which are all the other texts that readers use to make sense of and that therefore serve as a background against which he or she reads the primary text (Lemke, 1990). Without the intertexts, one would not be able to make sense, for “everything makes sense only against the background of other things like it” (p. 204). In the present situation, the caption and the photograph are about the same thing (co-thematic) and pertaining to the same activity structure (co-actional) but are of different genre (non-co-generic) texts. Texts and photographs are semiotic resources that are co-deployed (i.e., are systematically or strategically used together) and, becoming intertexts for one another, elaborate each other.

For the analysis of textbooks, I developed a scheme that articulates various semiotic resources and the nature of their relations (Figure 2.5). I view all relations between the different parts of a book (main text, figure, caption, and [sidebar] text box) as involving

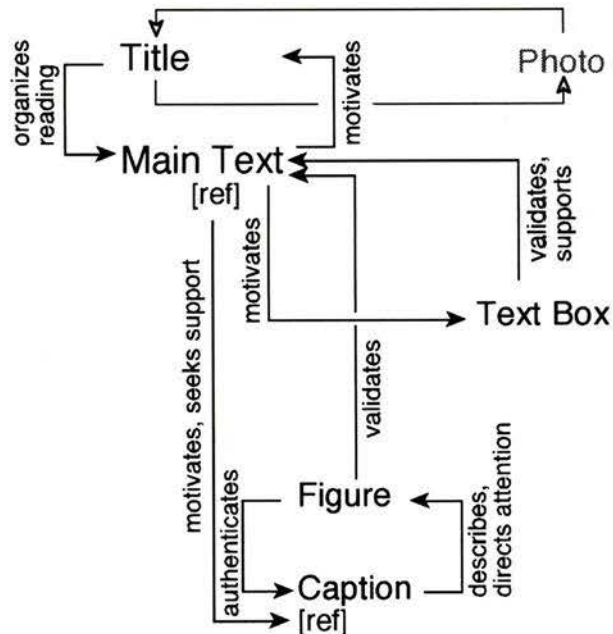


Figure 2.5. The framework that I developed for the analysis of inscriptions that accompany scientific texts in general and for photographs in particular.

double movements, each pair of entities mutually constituting one another and the relation. Thus, the title prepares the reader for what is coming, and thereby organizes the reading. At the same time, a title is not chosen arbitrarily, but has been motivated by the content of the main text. The main text makes certain claims or seeks to explicate a concept, which therefore motivates the use of a particular figure. The figure in turn validates the claims made in the main text. Finally, the caption describes and teaches how to read the figure (here photograph[s]) and the figure authenticates the caption text.

In this study, I am centrally concerned with the relationship between photograph (figure) and caption, and their integration with the main text. This integration is achieved not only through the co-thematic nature of figure and caption but also through an index (indexical reference) by means of which readers are referred from a particular place in the main text to figure and caption, which constitute a different genre. The caption is an

essential part of the inscription that tells the reader what to look for in the photograph and therefore how to read and understand it. The photographs are associated with a text (caption) that explains the phenomenon. Thus, photograph and text together form the written correlate of a demonstration (Morrison, 1989); they constitute a particular form of pedagogy. Therefore, important concepts and information should be placed in the main text, with the appropriate reference to the inscription that would help the reader to make sense of the phenomenon under scrutiny.

2.6. Photographs in Brazilian High School Biology Textbooks

In my analysis of the pedagogical role of photographs in high school biology textbooks, two themes emerged: there are different functions that a photograph/caption has with respect to the main text and there are different ways in which the photographs and the texts are structured, with implications for the interpretation of these inscriptions in the textbook. In the following sections, I describe and provide evidence for these two themes.

2.6.1. Functions of Photographs

In the ecology sections of the four Brazilian biology textbooks, all 124 photographs could be classified as fulfilling one of four functions (roles), which arise from the relation of photograph/caption to the main text. However, I also include in this classification those photographs that accompanied other inscriptions, as for example, maps. Series of or pairs of photographs were considered one single inscription in this classification. Therefore, the total of inscriptions classified in the four categories are $N = 148$.

I identified four functions including decorative ($n = 8$ [5.4%]), illustrative ($n = 52$

[35.1%]), explanatory ($n = 42$ [28.4%]), and complementary functions ($n = 46$ [31.1%]). These functions—and therefore my categorization—largely arise from the interpretation of caption, the text co-deployed and directly associated with each photograph. These functions also roughly define a hierarchy of increasing informational value (explaining a concept does more than simply illustrating a concept) and those with higher information value usually also do what the photographs of lesser informational value do. I exemplify and discuss each of these roles.

2.6.1.1. Decorative Function

A small number of photographs were classified as decorative. These photographs were not referred to in the main text, did not include a caption, and usually appeared at the beginning of a unit, chapter, or section of text. Figure 2.6, for instance, appeared on the opening page of a section on “energy and matter in the biosphere.” This photograph does not include a caption; there is no reference from the opening of the main text to the photograph. How the photograph functions in relation to other texts deployed (its intertextuality) requires analysis and does not “jump out” at the non-initiate. At the outset, it is a colorful plate from which relevant figure and ground have to be separated. Prior exposure to cultural categories allows readers of a certain age—a one- or two-year old may not perceptually differentiate what an adult sees as leaf or caterpillar—to identify a caterpillar on a leaf. That is, in the absence of a text inscribed in the book with reference to the photograph, the reader has to bring existing understanding as the intertext in reference to which the photograph becomes salient figure. What is the role of this photograph at this place in the book? What can a student learn by looking at or analyzing (studying) the photograph?

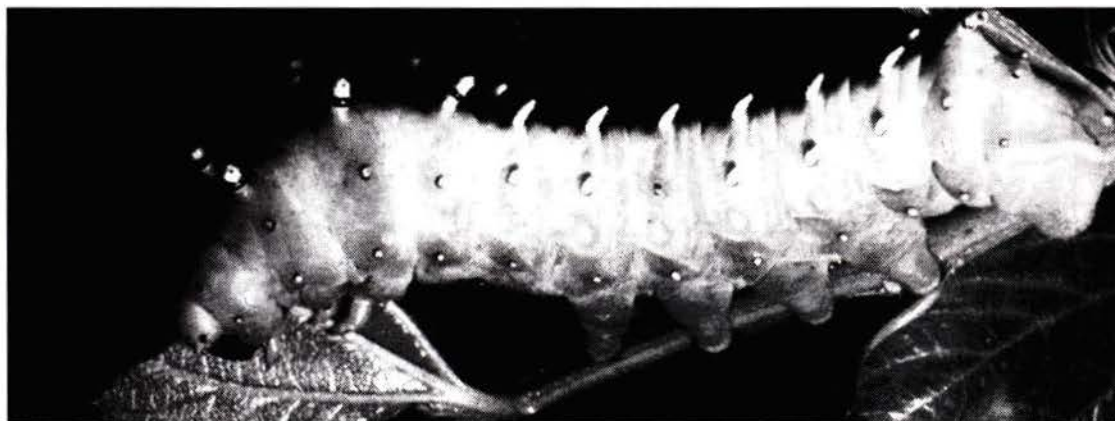


Figure 2.6. Example of a decorative photograph, that is, there was no caption accompanying it and there were no references to it in the main text.

A photograph can be viewed in many different ways. To understand what *this* photograph is intended to show in *this* place, a reader may search for clues in nearby texts, such as the title of the unit. Assuming that the text is not only co-deployed but also co-thematic with the photograph, a reader seeks to relate individual words “energy,” “matter,” or “biosphere” to the photograph. A somewhat initiated reader may see the caterpillar nibbling away on or “eating” the leaf; but I insist that “nibbling” as a process is not available to readers, it has to be inferred based on extra-textual experience. However, not until a reader knows the relationship between “eating” and “energy” can he or she establish a connection with (one part of) the unit title. At the same time, the leaf has to be understood as matter rather than as an organism, and both the caterpillar and the leaf have to be seen as aspects of “biosphere” before the relation of this photograph to the unit title can be established. Students, however, are not likely to bring this understanding necessary for establishing these relationships between unit title and photograph. In fact, the purpose of the unit is to develop the understanding necessary to deconstruct the relationship between photograph and title.

This initial analysis shows how, for the initiate reader, unit title and photograph can be seen in a mutually constitutive relation expressed in Figure 2.5. The word “energy” makes a reading of “caterpillar eating leaf” a reasonable reading of the photograph, which, in turn, establishes a concrete instance of the relationship between biosphere and “matter and energy,” concepts usually introduced in the physical sciences. However, students will know the content only after they have finished studying the chapter; it is therefore unlikely that they bring the interpretive resources required for the type of analysis provided. Furthermore, there was also no text that could guide students in their analysis of the image. I therefore categorized such photographs as decorative. They introduce color, may provide for certain aesthetics, but lack informational function for the individual who does not already know what the subsequent text is intended to teach.

2.6.1.2. Illustrative Function

Photographs included in this category include a caption that names or describes what the reader is to see in the photograph but the caption does not provide additional information to the main text. Such photograph-caption ensembles constitute a visual resource for the reader in the sense that a concrete specimen of a class or concept is depicted (e.g., Figure 2.7).

This photograph gives the reader a visual representation of the species mentioned in the main text (aguapé), but this is not an essential piece of information for the reader relative to the subject matter treated in the text. In the present case, the subject matter is the introduction of certain species in biomes, exemplified by the introduction of aguapé in hot regions. “Aguapé” and “hot regions” are special instances of the more general concepts of plant and biome.

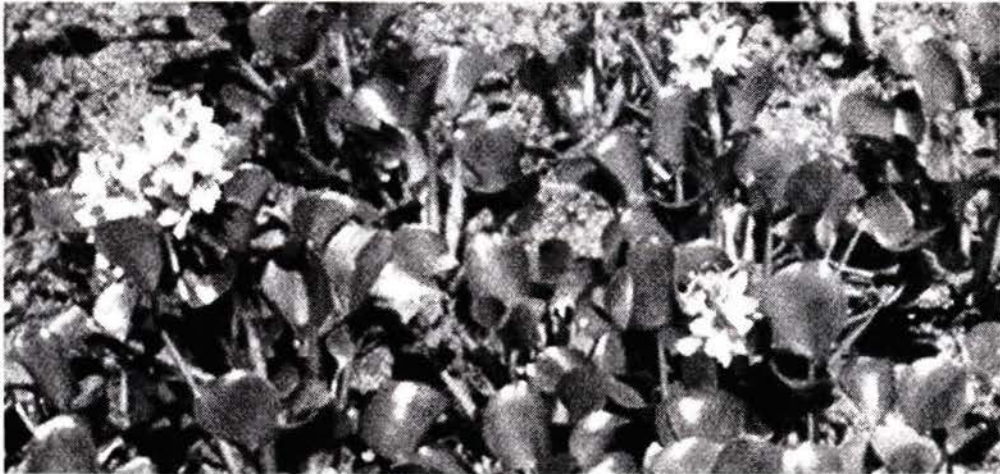


Fig. 4.3 Photograph of plants of aguapé in blossom.

Figure 2.7. Example of an illustrative photograph, which includes a caption that names the object or phenomenon but does not provide other semiotic resources.

The photograph illustrates the particular plant but does not show “introduction” that causes changes in the ecosystem. To show the effect of “introduction” of a plant, a minimum of multiple photographs are required that show some difference that can be noted as a difference before it, according to Bateson (1972), can function as “information.” That is, if there is not a difference that makes a difference, we cannot speak of information at all. Therefore, the very concept taught in the text is absent from the photograph: it does not exist as information in the image. The visual information possibly provided does not alter the understanding of the subject matter, that is, the photograph does not show the phenomenon treated in the text, but provides a visual illustration of a plant that was only referred to in the text as an example of a species the introduction of which caused changes in the ecosystem. The reader is still able to understand the concept of ecological disequilibrium treated in the text without the information provided by this photograph and the caption.

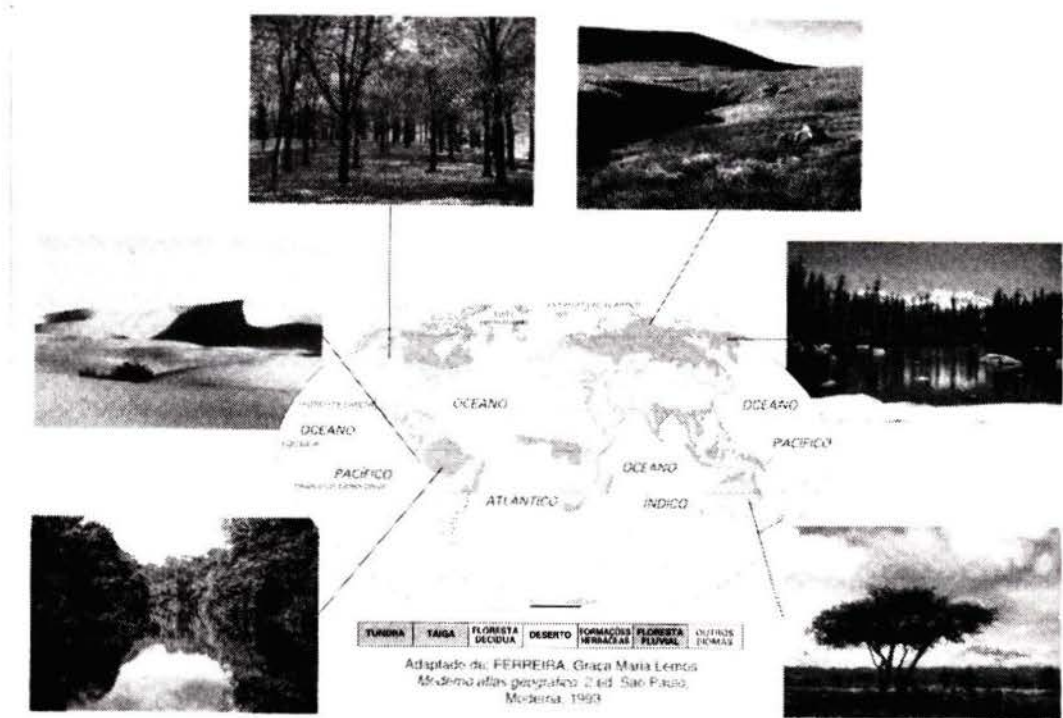


Fig. 7 Large biomes of Earth.

Figure 2.8. Example of a special case of illustrative photographs, each ecozone identified in the map exemplified by one member of the category.

There were several cases ($n = 29$) of illustrative photographs that were not associated with a (part of a) caption. Such photographs, a special case of photographs without caption, appeared together with “maps,” the dominant aspect of the inscription (Figure 2.8). Here, several photographs were co-deployed with the map but were not described or explained in the caption. One might therefore think that the photographs are decorative, especially because the caption of the inscription is related to the map. However, there is an important link between photographs and map: the color scheme of the legend relates to photographs, presenting single (paradigmatic) instances of different landscapes, and regions. Each one of these photographs therefore is an illustration of one type of biome. If map and photographs are interpreted as being co-thematic, by virtue of appearing in the

same plate, the different genres can be read as linked via the concept of biomes:

“distribution of different *biomes*” and concrete instances of individual biomes. In this situation, there is one photograph for each biome but, in the presence of six images, a contrast is provided between what may be prototypical examples for each biome. The presence of only one example does not allow students to learn what characterizes each biome or more poignantly, how to distinguish one biome from another in more problematic cases near the border of the category. (See Lakoff [1987] on examples of a category that are nearer the center, and therefore more prototypical for a category versus those that are nearer the peripheries of two categories, and therefore more problematic in their assignment to one or the other.) But the presence of six prototypes, given learners attend to appropriate aspects of the landscapes depicted, may allow the recognition of some global distinctions between these biomes. Nevertheless, some of the very features that distinguish these biomes, the amount of water available, temperature, and other physical and biological information, are not accessible by students through the analysis of the photographs.

2.6.1.3. Explanatory Function

This category includes photographs with captions that provide an explanation of or a classification of what is represented in the photographs. The captions do not only name the object or phenomenon in the photograph, but also add information about this object or phenomenon. Take the example of Figure 2.9. In the first part of the caption one can read “Aspect of a forest.” With this information, readers are guided in what to look for in the photograph, a forest. That is, what one sees are not just a group of trees along a river but part of a larger whole. This information provided by the caption is important in helping



Fig. 84.1- Aspect of a forest: climax community.

Figure 2.9. Example of an explanatory photograph. The words “climax community” provide a frame that allows the reader to establish a connection between the figure and the main text.

the reader to make sense of what can be seen in the photograph, however, this information is not enough to guide the reader to establish relations between the photograph and the subject matter treated in the main text.

The index presented in the main text and replicated in the caption allows the reader to connect figure and text. However the reader is not able without further information to appropriately relate the “forest” in the photograph with the concept of “ecological successions” that is the corresponding topic of the main text. Thus, if this were the only information provided in the caption, the photograph would function as an illustration of a forest, because somewhere in the main text the forest was mentioned. It is the second part of the caption that provides the information necessary to interpret the forest in the photograph as “something else,” which allows the reader to explicitly relate

the figure and the text. The two words, “climax community,” represent an entire different perspective in the way in which the reader contextualizes the photograph and relates it to the main text.

The photograph not only represents a forest, but also is *marked* as an example of a climax community. Textual marks are not neutral but invite making salient some things to the exclusion of all the others that could be made salient (Derrida, 2001). That is, marked terms encourage readers to associate the characteristics of a climax community described in the main text with what they see in the photograph. In this sense, this caption not only classifies the forest as a climax community, but also provides an explanation about how to interpret and relate the photograph with the main text.

At the same time, because this is a single photograph, the concept of succession is not available to readers, which would require several photographs showing the same physical location but with varying cover corresponding to varying stages in the ecological succession of the area. Similarly, the single photograph does not allow the non-initiate reader to learn how to distinguish climax forest from non-climax forest, or between the climax forest for different forms of succession such as those that end in maple-beech forest (Northeastern US, Eastern Canada) or those that end in coniferous forests (Canadian shield, Newfoundland). Both types of forest are examples of climax forest but are very different in the way that they appear to the eye.

2.6.1.4. Complementary Function

Photographs in this category are associated with captions that add new information about the subject matter treated in the main text. This information is not only new, but it is also an important information, never mentioned before in the main text, and that helps

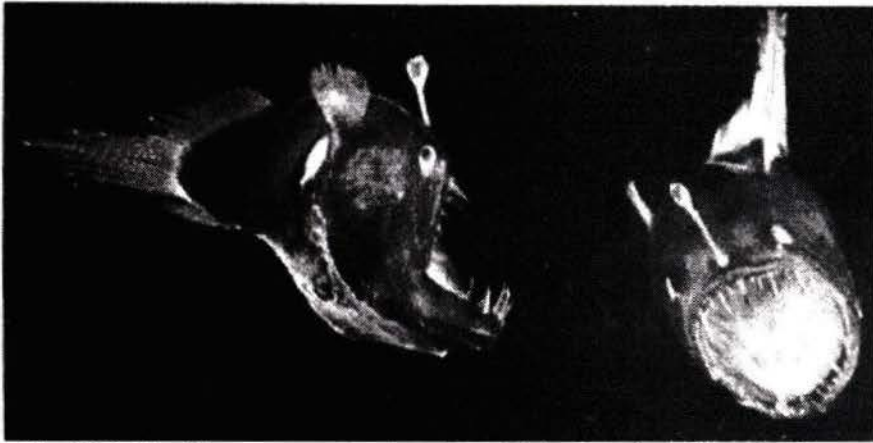


Fig. 86.6- Linofrino, an example of an abyssal fish, about 5 cm long, that lives at a depth of 1400 m in the ocean. The abyssal fishes usually are small and with dark colour, and have sensitive eyes.

Figure 2.10. Example of complementary photograph: The caption names the object/phenomenon represented in the photograph, provides an explanation or classification of this object/phenomenon, and contains new information, not available in the main text, about this object/phenomenon.

readers to further understand the biological concept that is being taught. Figure 2.10, for example, presents two fishes against a black background. The title of the section of the text where this figure is inserted in is “Influence of light in the marine ambient,” and in the main text one can read about the distribution of species in the ocean according to the presence or absence of light. In the last paragraph the text presents some characteristics of fishes and other animals that live in the abyssal zone. Then the text refers the reader to the figure.

The text in the caption begins by providing a name and articulating it as an example of an “abyssal fish.” Inherently, the statement “linofrino, an example of an abyssal fish” requires the cultural competence of associating the name with the image, even though there is no specific index linking the name with the fish—parents reading to their preschool children might place their finger on the image and say, “linofrino.” The

remainder of the caption provides propositions with content not made available in the main text, and therefore constitutes new and relevant content. I therefore classify this photograph-caption ensemble as complementary.

The caption in this case provides information about what can be seen in the photograph, that is, characteristics of the abyssal fishes represented. The caption also adds *new* information, not directly related to the two fishes, but, rather, associated with the concept of abyssal fish treated in the text. Therefore, this plate constitutes a “complement” to the main text. The complementary photograph/caption thus presupposes continuity in the reading process, as readers iterate their reading between main text and plate. They are able to make sense of the concept presented only through the reading of all the information contained in these three elements. *If* the information in the caption is new and important, I therefore have to ask why this information is in the caption instead of in the main text—unless photographs/captions are regarded by students and teachers integral parts of the “material to be studied.”

2.6.2. Structures of Co-Deploying Photographs and Texts

My analysis reveals considerable variation between and within textbooks in how the co-deployment of photographs (Figure 2.5) and texts is structured. The structural elements and the relation between them are diverse among the selected textbooks and even within the same book. The variations include, for example, *where* the indexical reference to a photograph occurs in the main text, the distribution and arrangement of photographs on the page, and the co-deployment of multiple photographs for teaching a particular concept. These structural elements, undoubtedly, provide different semiotic resources for integrating co-deployed and co-thematic but non-co-generic text.

2.6.2.1. Indexical Reference

Photographs represent a different genre than text. They are two-dimensional arrangements of colored or black-and-white areas, which, because of our prior experience in a three-dimensional world, can be decoded to provide additional information about depth. Color, areas covering other areas, relative size of known objects and so forth provide resources for reading that are deployed as the eyes scan the image according to the reader's preference. Because of the different requirements for reading verbal text and images, the latter cannot be placed at the point in the text that is directly pertinent (co-thematic).⁶ The link between the text (word, sentence, or paragraph) and the photograph that appears somewhere else on the same or different page is established via an indexical reference usually as a string of letters and numbers in the form "Figure 1.2," "Fig. 2," or "see Fig. 3.4." A copy of this index is also found in the caption of the figure that the index is designed to direct the reader. Here, the indexical function is achieved by duplicating a string in the main text and in the caption. Whenever the string appears in the main text, the reader is referred to the photograph/caption that features the same (co-generic) string. That is, the relationship and "placement" of a photograph with respect to the dominant text is achieved by means of a string that appears twice but in different locations on the page or in the book. The role of the string is salient when we consider that a similar relationship does not suggest how to link caption and photograph. Here physical proximity is used to suggest that the text directly bears on something in the image. How this bearing might be achieved still remains undetermined at this point. (I

⁶ Multimedia such as web pages allow different ways of accessing images, for example, by making available a "button" linked to an image so that the reader can, if desired, make the image appear in a new window, which itself may be moved around the monitor.

discuss the nature of this relationship and how the reader enacts it in the next section.)

Two textbooks consistently used the same way of referencing photographs/captions either placing the indexical reference at the end of a paragraph in which the co-thematic concept appeared (Amabis, 1997) or not using an indexical reference at all (Soares, 1999). The two other books each employed three different ways in placing the indexical reference in the main text. Thus, the indexical reference was placed either at the end of the paragraph or directly with the co-thematic word or sentence or was absent altogether.

When the indexical reference is placed immediately after the word or after/within the sentence that is co-thematic with the photograph/caption, a *direct* link is established between what are on the surface different (because non-co-generic) representations (Figure 2.5). On the other hand, if the indexical reference is placed at the end of a paragraph where there are potentially multiple concepts presented, the link is no longer direct. One might consider the index “misplaced,” because the photograph/caption is not evoked simultaneously with the verbal texts. There is the potential that misplaced indexical reference in books interferes with sense-making processes in ways similar to misplaced gestural indexical reference that make it difficult to learn from lectures (Roth & Bowen, 1999a). Finally, when there is no indexical reference at all, it is totally up to the reader to see whether there is any relation at all between a photograph/caption on the main text on the same particular page.

Figure 2.11 exemplifies a “misplaced” indexical reference. In this situation, because the index is placed in the end of the paragraph, the reader may associate the photograph more spontaneously with the last phrase or statement—particularly in those textbooks where the indexical referencing changes. The photographs represent (1) a burned area

a.
 Factors of Ecological Disequilibrium
 Changes in the structure of ecosystems
 Deforestation

One of the most important ecological problems today is the destruction of forests, as these occur with the Atlantic Forest in Brazil. Today less than 10% of this forest type remains compared to the period of colonization. Each year, the world loses forest areas; forests are cut or burned, leading to serious soil damage and causing atmospheric pollution. Furthermore, many species become extinct, thereby decreasing “global biodiversity,” as scientists call the large variety of living forms produced by biological evolution. (Fig 4.1)

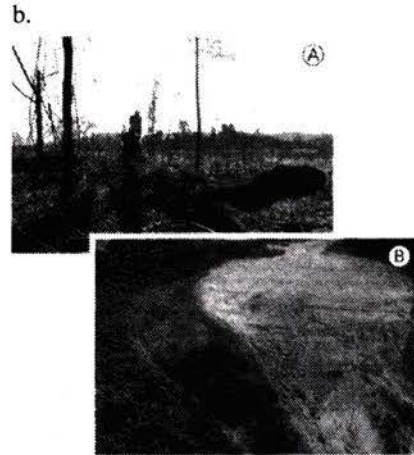


Figure 4.1 Deforestation is a common way of damaging terrestrial ecosystems. (A) Photograph of burned area in the Amazonian Forest, used to create pasture areas for livestock farming. The fire kills the microorganisms that fertilize the soil, and the rains wash the nutrients away since the vegetal coverage was destroyed. (B) Photograph of regions of soil erosion provoked by the elimination of the forests.

Figure 2.11. Example of an inscription with a “misplaced” indexical reference. a. Main text. b. Photograph and caption referred to at the end of the corresponding paragraph in the main text.

and (2) an area of erosion of the soil. Although the main text mentions burning and cutting the trees as ways of causing deforestation, the index to the photograph is physically far away from the specific phrase where deforestation is mentioned.

To associate the photographs with the main text, the reader needs to go back to the middle of the paragraph and find the specific phrase that refers to deforestation. Then, the reader must go back and forth in his or her attempt to read the text. This reading requires the reader to work from the text and the photographs, at the same time “reading” and “seeing” to make sense of the biological concept presented.

Figure 2.12 presents an example of an inscription with no index in the main text. This inscription presents two photographs: the photograph to the left shows a river with



Figure 10 Quantity of water and richness of life are interdependent.

Figure 2.12. Example of a photograph without any indexical reference in the main text.

abundant vegetation in both its banks, and the photograph to the right shows a desert. The caption reads, “The amount of water and the richness of life are interdependent.” Because the main text does not contain an indexical reference, one can only try to establish a relation between text and photographs, the relationship of the photograph to the main text can only be subsequent to reading the entire main text section and the photographs/caption.

When the photographs appear alongside one another, the composition highlights the importance of water for the existence of life. Thus, through a comparison of both photographs, the reader is supposed to associate life and water in the way intimated by the caption. However, this is just one way to interpret this inscription, and many other interpretations can also emerge since there are no explicit directions or enough information in the main text or caption to help the reader to make sense of this.

The situation becomes even more difficult when the photograph is physically placed

far away (several pages) from the corresponding text (e.g., Soares (1999), p. 311). In this situation, the reader will find him- or herself completely “lost in the book,” since he or she will not find any direct association between the text and the figure, because of the absence of the indexical reference. Furthermore, the reader will have difficulty to manage the book pages to associate the figure with the text, because of the disposition of the inscription many pages after the one in which the text was placed. At this point, the figures even though associated with captions, may serve decorative rather than higher functions in the text.

2.6.2.2. Single and Multiple Photographs

The arrangement of the visual document within the text mediates our ability to see the phenomenon represented in the photograph, that is, part of our interpretation of the photograph depends on the way in which the figure is organized, and how the photograph relates to other photographs. One way in which a photograph can be related to others is as part of a pair or of a series. Photographs arranged in series allow the reader to progressively focusing his or her attention on the concept examined by the text. Consider for instance Figure 2.13. At a first glance, the reader may see these two photographs as presenting the same butterfly, due to the enormous similarity between the species represented in both photographs. However, the caption cautions the reader that the photograph at right presents one species of butterfly, and that, actually, the butterfly in the photograph at left only seems to be the same species as the earlier, thereby constituting the phenomenon called “mimicry”.

The authentication of the phenomenon of mimicry presented in the main text is possibly due to the arrangement of the photographs in a pair, which allows the significant

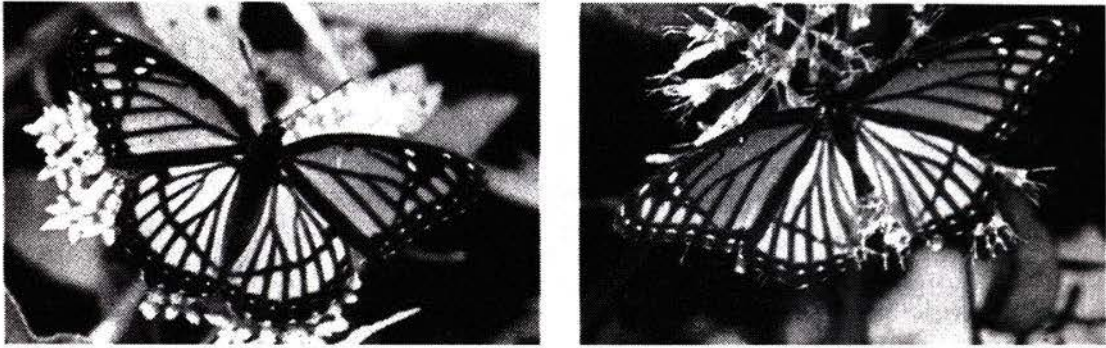


Fig. 581. At left, the viceroy butterfly. At right, the monarch butterfly, which has repugnant taste for the birds. Because of the similarity between them, many birds reject the first one, which therefore benefits from mimicry.

Figure 2.13. Example of photographs arranged in pair, which allows the reader to look for variant and invariant properties.

differences to become evident through the process of comparison. Nevertheless, a comparison between the two photographs is not enough to give the images meaning. The caption is also necessary to guide the reader to look for the differences—instead of the similarities that are more evident in this case—between the two photographs, to recognize the phenomenon of mimicry. Similarly, in a series of photographs, as for example in Figure 2.4 (p. 26), the process of authentication of the phenomenon presented in the text depends on the reader's perception of the differences between the photographs. In making the photographs part of a series, the uncertainty about the meaning is reduced, and the reader, then, is able to eliminate everything that does not change, in a process that progressively highlights what there is to look at and make sense of in this figure.

Another way in which a photograph can be related to others is when it presents the same object as another photograph, but in a different way, which allows both photographs to become complementary to each other (Figure 2.14). The first photograph shows the plant in a broader view, while the second photograph focuses on a specific part

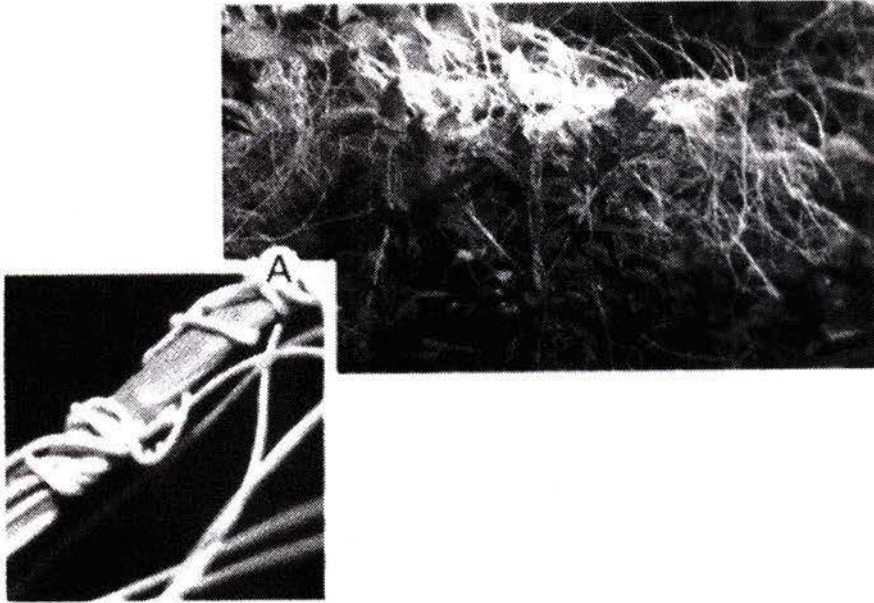


Fig. 3.10 (A) Photograph of a Hibiscus plant covered by the cipó-chumbo. In the detail, in higher magnification, the relation between the parasite and the stem of the host plant.

Figure 2.14. Example of multiple photographs, one being described by the text as presenting the detail of the other.

of the same plant. Together, the two photographs allow the reader to identify the plant in the way in which it could appear in nature, and, at the same time, pay attention to the specific detail relevant to the concept presented by the main text. Both photographs, therefore, function in a complementary way to one another, the second photograph becoming “part” of the first one, as a detail in higher magnitude, that provides the reader a better visualization of the phenomenon treated in the broader photograph and in the main text. Multiple photographs, therefore, allow the reader to make external comparisons and therefore visualize the phenomenon presented by the main text. A single photograph, however, can only provide internal comparisons, leading the reader to find the relevant details in the photograph on his or her own.

2.6.3. The background of the photograph



Fig. 83.1- Epiphyte plant

Figure 2.15. Example of photograph that carries too much information and it is unclear which of the many plants is the “epiphyte plant.”

In the process of interpreting single photographs, the background becomes an important resource to help the reader to distinguish the relevant object/phenomenon depicted in the photograph. Explicit directions in the caption and other indications, as for example, letters or arrows added over the photograph itself, are also important resources that guide the reader’s attention to the “right” detail. Thus, Figure 2.15 fails to demonstrate the object that it should represent according to the caption. The caption reads “Epiphyte plant,” but there are many different plants without distinction in the photograph that could be identified as the epiphyte plant. Even though there is a tree placed in the center of the photograph, which may draw the reader’s attention, it is not possible to identify the epiphyte plant, unless the reader already knows what to look for. That is, the reader has to know what an epiphyte plant looks like in order to find it in this photograph. The difficulty, in this case, is related to the “framing” (Bastide, 1990) of

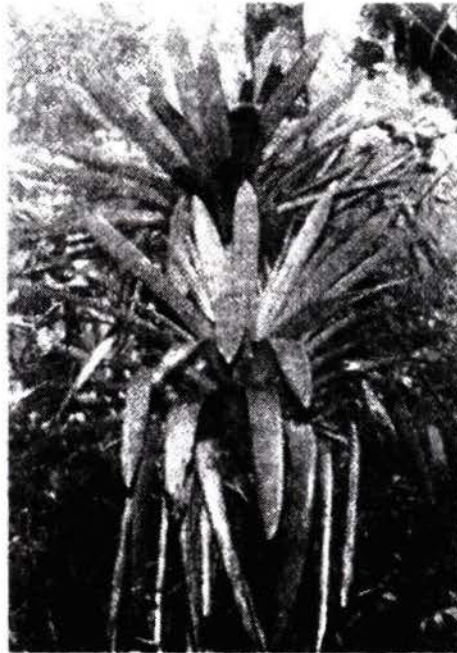


Figure 3.9 Photograph of the interior of a tropical forest, showing epiphyte plants, associated with host trees by inquilinism.

Figure 2.16. In this photograph it is possible to identify the epiphyte plants, even though it still presents other plants in the background.

photographs, that is, the process by which the reader narrows the perceptual field to eliminate as many irrelevant elements as possible from the background while trying to show the object as a whole.

The aim in framing photographs therefore has to be making sure that it contains the least information possible, for fear of confusing the meaning. The details in the background seem to carry no relevant information at all, despite their function of making the photograph more “natural,” because it can be perceived as a depiction of a particular piece of nature. However, the effect of realism does not depend on the complete reproduction of the world, but on the viewer’s perception of the narrative and perceptual order (Myers, 1990). Therefore, it could be more appropriate, at least in certain situations, to present an object against a neutral background, even if it compromises the ‘reality’ of

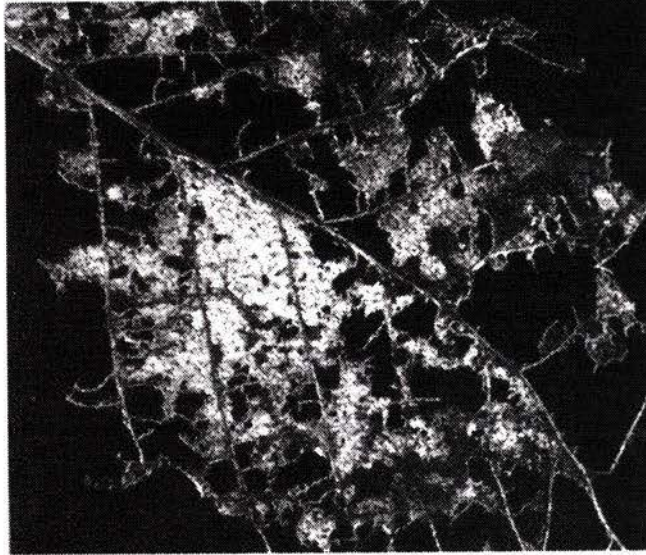


Figure 18. The organic matter is decomposed by bacteria and fungi, as we can see in this photograph of a leaf that has fallen on the ground months ago and is in final process of decomposition.

Figure 2.17. The black background highlights the object represented in the photograph.

the photograph as a depiction of the real world. Compare Figure 2.15 to Figure 2.16, which also represents an epiphyte plant. The relevant element in this photograph—the epiphyte plant—is clearly distinct from the background, even though the photograph still presents other plants. The epiphyte plant is not only in the center of the photograph but also the only object that the reader can clearly distinguish. The figure was framed to show just this particular plant, and all other objects are out of focus, becoming part of the irrelevant details in the background.

Sometimes a completely black background is a better alternative for highlighting the phenomenon or object in the photograph (Figure 2.17). The reader is immediately directed to whatever is shown against the black background that is easily identifiable as irrelevant. Thus, the arrangement of the photographs in the books, as well as the intrinsic characteristics of the photographs themselves, have an impact on the process of

interpreting the figures, and consequently, in reader's ability to relate the photograph with caption and main text.

2.7. Discussion

We live in a visual culture and visual representations pervade our lives. This is especially true in the sciences that historically are associated with the emergence of representational practices. In this study, I showed that photographs are the most frequent inscriptions in textbooks and can play different and important roles in the texts and that the photographic images and captions are often inappropriately referenced from the main text. That is, the photographs and captions almost function in a stand-alone mode.

I began this study of photographs because my informal survey of students at all levels of education showed that they hardly ever attend to the photographs despite their abundance in the textbooks. This tendency, of course, has to be seen in the context of school science and university lessons that primarily focus on language (and mathematical formulae) as a carrier of scientific knowledge. I hypothesize that the true potential of photographs as pedagogical resources has not yet been achieved. To better understand current and potential future use of photographs in science lesson, I presented a framework for analyzing photograph and provided an initial analysis of photographs in four major Brazilian biology textbooks.

My analysis of the photographs revealed that the structural elements and the relations between them are diverse among the textbooks and even within the same textbook. Although the main function of the caption is to help understand and interpret the photograph, the "information" in the caption can vary, alternating the relations between the whole inscription and the other structural elements of the text. This alteration also

changes the role of the inscription in the text. I identified four functions of photographs, decorative, illustrative, explanatory, and complementary.

These differences in the information provided by the caption not just influence readers' interpretations of the photograph and therefore what they can learn from them but also change the role of the inscriptions in the text. For example, one can infer from a photograph without any caption that, because there is no direct association to the text, its role is a "decorative" one, and so the book is more "beautiful," "colored," and "full-illustrated." A caption that just identifies what is represented by the photograph gives the reader a clear idea that this photograph is playing an illustrative role. In these cases it is not even necessary to have the picture; it is a supplement to the text, adding details or specificity, or illustration of it. But as Derrida (1981) points out a supplement is part of and not part of the text at the same time: it seems to be adding something to what is complete in itself, and the addition is thus implicitly a correction, sometimes to the point of a recantation.

The indexical reference in the main text also varies in the four textbooks and even in the same book. Two of the four textbooks analyzed present patterns related to the index; one of them always presents the index in the end of the paragraph, and the other one does not have an index at all. The other two books present three different ways to place the index in the main text: in the end of the paragraph; in the middle of the text, just after the phrase or the specific word related to the inscription, or with no index at all. The way in which the index was written also varies in these two textbooks, that is, "(Figure 1)", "(see figure 1)", ". . . as we can see in Figure 1," etc. My analysis showed that these differences in the indexical reference can change or reinforce the role of the inscriptions in the text

and that relations can be established between the photographs and the other structural elements of the text.

I conclude that textbook authors use many strategies for relating photographs to titles, main text, indexical reference, and captions. The capacity of individual photographs to illustrate a concept appears to be limited because variation between exemplars, although not expressed, is necessary to understand just what a photograph depicts. (For example, Law and Lynch [1990] show that novice birdwatchers have difficulties matching a bird to one of the photographs in their bird guide.) Some of these ways appear to interfere with sense making, whereas others potentially offer support in the construction of meaning. Evidently, misplaced indices, that is, indices that “point the reader in the wrong direction,” disrupt the making of sense.

2.8. Implications

My analyses of the way in which photographs are used in the textbooks have some implications for (1) textbook authors and (2) textbook readers, including teachers and students. My work implies that textbook authors and publishers need to attend to the appropriate integration of the different representational means so that they in fact assist students in making sense. Further, the use of single photographs often does not allow a reader to disclose what really matters—(time) series or contrasting photographs, on the other hand, make salient variation that are more likely to lead readers to identify the crucial and learning-enhancing aspects. Some important topics to which textbook authors should pay careful attention when selecting photographs are briefly addressed here.

The caption: Every photograph should have an appropriate caption associated to it via an indexical reference in the main text. An appropriate caption may contain more than

just an identification of the object/phenomenon presented in the photograph and referred to by the main text. The caption should add enough information such as to guide the reader through a perceptual analysis and therefore interpretation of the photograph, identifying relevant details and associating the figure with the main text.

The indexical reference: The figure (photograph and caption) should be explicitly associated with the main text via an indexical reference, preferably placed just after the first time the object/phenomenon of interest is mentioned in the main text. This would allow the readers to easily relate figure and text, significantly narrowing the possibilities of misinterpretations of the photograph.

Multiple photographs: Time-series or sequences of photographs, in some situations, are preferable to single photographs to represent complex phenomena or changes. Pairs of photographs that allow comparison or that provide a magnified view of an especial detail of an object (or a broader view of a small object) potentially work better than single photographs.

Background: When making use of a single photograph, special attention to the photograph itself is necessary. The background of the photograph should be easily recognized as such, that is, the object/phenomenon of interest represented in the photograph should be highlighted against its surroundings. Centering and focusing the relevant object/phenomenon in the photograph are ways of emphasizing what is important. Making use of neutral backgrounds, for example black backgrounds, is an efficient way of highlighting the object/phenomenon when it does not suffer from decontextualization. In some situations, arrows and other signs directly placed over the photograph can also help to distinguish the important details in the photographs.

Pertaining to readers, anecdotal information shows that students and teachers often do not attend to the photographs and their captions while perusing textbooks. If, however, there is information to be obtained from the dialectically related caption and photograph, students miss out on an important resource for understanding the topic that they study. Teachers and students need to pay more attention to the possibilities of photographs to enhance understanding of textual information. Perhaps the photographs could become themselves objects of discussions, which would allow students and the teacher to develop insights about how and what others see when they look at a photograph, and how they interpret it in the context of various other textual sources provided on the page. Further study, however, is needed to address these and other important issues related to the pedagogical potential of the photographs for students and teachers who make use of textbooks. I suggest that future studies focus on students' and teachers' interpretation of photographs (cum caption and main text) in real time.

2.9. Acknowledgments

I thank the authors and publishers of the four textbooks for their permission to use the photographs and texts that I analyzed in this article. The research was made possible, in part, by Grant 410-99-0021 from the Social Sciences and Humanities Research Council of Canada (to Wolff-Michael Roth). All opinions are my own.

Chapter III

Photographs in Lectures: Gesture and Body Orientation as Meaning-Making Resources

Abstract

Photographs are the most frequent visual representation in high school biology textbooks. However, little is known about how students make sense of and learn from photographs when they come across them; even less is known about the different resources available for making meaning of photographs when these appear in lectures. In this study, events during which individuals used photographs in lectures and lecture-type situations were culled from a database established during three ethnographic studies and analyzed with respect to the meaning-making (semiotic) resources that speakers standing next to the projected photographs provided for understanding and learning from them. My analysis, methodologically informed by interaction analysis, identified eight types of gesture/body orientations as semiotic resources that decreased the ambiguity inherent in photographs. I describe these eight types in detail and show in which respect they enhance the understanding of photographs and the scientific concepts embodied in them. Differences are noted with events where photographs are projected so that the speaker did not stand next to the projected photograph (e.g., overhead projectors, darkened lecture halls). I surmise that teachers can help their students learn to read and interpret photographs from lectures when they project reproductions against a screen in such a way that it allows the use of gestures and body orientations as additional meaning-making resources.

3.1. Introduction

We live in a visual world: (visual) representations pervade our lives. This is especially true in the sciences, where scientists rely heavily on the use of visual representations when they talk shop in scientific research laboratories and when they write research articles (Knorr-Cetina & Amann, 1990; Latour, 1993). Following the usage in the social studies of science, visual representations in any medium (paper, computer monitor, projected image) are now referred to as “inscriptions” in the educational literature, too (Roth & McGinn, 1998); inscriptions include photographs, maps, charts, diagrams, graphs, formulas, and so forth (Latour, 1987). Inscriptions are of particular importance to the construction of scientific objects and to the construction of scientific knowledge both at the level of the individual laboratory and at the level of the scientific community (Henderson, 1991); they constitute a pervasive means of scientific communication.

It should not come as a surprise then that scientists and science teachers at all levels of schooling also draw heavily on inscriptions when they communicate the current state of the art to the next generation of scientifically trained individuals both in textbooks (Roth, Bowen, & McGinn, 1999) and in lectures (Roth & Bowen, 1999). What may perhaps come as a surprise is the fact that the frequencies of particular inscriptions differ between high school textbooks and scientific journals. Thus, despite nearly the same number of inscriptions per page, there is a prevalence of graphs, statistics, and mathematical formulae in scientific journal articles whereas high school

biology textbooks contain a large number of photographs and naturalistic drawings (Roth et al., 1999).

In the previous chapter I showed that a number of structural features of photographs in Brazilian high-school biology textbooks pose potential problems for making sense from the photographs. Because of the abundance of contextual detail, photographs lend themselves to being perceptually structured and therefore interpreted in different ways so that what exactly is important to the scientific phenomenon to be taught is often not discernible by the reader. My previous study showed that neither caption nor main text were able to constrain this tendency of photographs to proliferate meanings rather than to constrain the number of ways readers can make meaning when they read a particular scientific text (Bastide, 1990).

When presenters or teachers use photographs during a lecture, one may expect them to deploy meaning-making resources not available to the reader of a text. For example, under certain circumstances, one can expect lecturers to use gestures, pointing sticks, or lasers to point to a particular spot in the photograph; linguistically, such pointing constitutes a *deictic* gesture (McNeill, 1992). Furthermore, lecturers can also use *iconic* gestures, which get their name from the perceptual resemblance of gestures with the phenomena they depict—following the shores of a lake on an aerial photograph or using two hands to illustrate the confluence of two creeks constitute iconic gestures. That is, learning from photographs in the context of lectures can be expected to be a very different kind of work than learning from photographs in textbooks.

The purpose of the present study is to investigate the semiotic (meaning-making) resources that lecturers make available to their audiences; such resources can assist in better understanding just what photographs are intended to express. I study cases in which speakers talk about scientific topics in the presence of photographs. I focus on “lectures,” that is, situations in which one speaker talks about scientific issues while addressing a larger, mostly listening audience. I analyze talk, gestures and relative position of speakers with respect to audience and to photographs, with a particular interest in how a speaker’s words, gestures, and body orientations assist in making salient photographic detail pertaining to the scientific issues at hand.

3.2. Background

When scientists interact with other scientists and when they teach and make use of inscriptions, they do not only speak but also gesture, point, and create and move in real and imaginary spaces (Goodwin, 1995; Ochs, Gonzales & Jacoby, 1996). In these situations, inscriptions and (verbal or written) text are co-deployed such that meaning is simultaneously multiplied (Lemke, 1998) and constrained to allow only a limited range of meanings (Bastide, 1990). This study is situated at the intersection of two domains of scholarly work in the context of scientific communication: semiotics of photographs and associated text and gesture studies as these disciplines pertain to science and science education.

3.2.1. Semiotics of Photographs

High school biology textbooks heavily draw on photographs; one might think that this means a lot of information is made available by visual means. However, photographs alone contain too much undifferentiated information and therefore mean little; they are full of “gratuitous” detail that allows many different ways of looking at and interpreting them (Myers, 1990). On the one hand, this photographic detail provides a space that is quasi-continuous with the lived world, allowing readers to establish a link with the everyday world that surrounds them. On the other hand, this detail provides few cultural codes that could delimit the photograph’s sense and meaning as intended by the author. To control the range of possible meanings that a photograph can give rise to, authors use captions and embed the photograph/caption combination in still further text (main text) that together constrain the meaning a reader can make (Bastide, 1990). That is, the text constitutes a specification of order of coherence from which the rational visibility of the scientific object emerges. Therefore, when there are only photographs and texts, such as in science textbooks or scientific journals, the work of reading, in part, consists of uncovering how caption, main text, and photographs are linked, as shown in Chapter 2. Reading is required to construct and reconstruct the orderly sense of the scientific findings and concepts presented. The text provides particular constraints in terms of how it orders readers’ ways of looking at photographs; the text therefore constitutes a particular pedagogic arrangement.



“What is happening here is that if rain is falling on the land it would fall onto these mountains and it would drain either down one side or down the other side. So little creeks would form up here and they drain into a bigger creek, and into a bigger creek, and drain all the way down into this larger area.”

Figure 3.1. Example of a photograph and a lecturer’s utterances that explained what the audience is to see in it.

The situation is different, however, when we consider photographs in the presence of a verbal instead of a written text. Consider for instance the photograph in Figure 3.1 and the text produced by the person talking about it. If this photograph and the associated text were part of a textbook, readers would certainly have some difficulties to interpret this figure. For instance, which mountains are “these mountains”? Where, in the photograph, is the “other side” referred to in the text? What exactly does the utterance “up here” refer to in the photograph? From the use of terms such as “here” and “this,” which are inherently context sensitive, one can infer that the text associated with the photograph in Figure 3.1 is not part of a textbook. If one considers the text and the photograph in Figure 3.1 as part of a speech situation such as a lecture, for example, one can interpret it in a different way. In this example, the audience has to rely on peripheral clues for interpretation. It has to take into account not

only the established text but also the clues provided by the context to make sense (Brown & Duguid, 1992). However, even realizing that the text accompanying the photograph in Figure 3.1 is not a written but a spoken text, the problem of identifying the “right” objects in the photograph is still present. Further resources are necessary to enable audiences to make sense of this photograph and text. In a speech situation these resources consist, for example, in the gestures and body orientations that speakers use during their talk. It is, therefore, as if the two classes of organizational materials, text and photograph, are linked through and coordinated by the gestures and body orientations. This paper is centrally concerned with speakers’ gestures and body orientations as resources produced as meaning-making (semiotic) resources for the audiences.

3.2.2. Talk, Gesture and Photographs

In a speech situation, such as a lecture, speakers and listeners make available to each other resources (body movements, gestures) that allow coordination of speech in particular, and of the entire interaction more generally. There is evidence that listeners actively interpret even highly idiosyncratic gestures and use them as resources to make sense (Kelly, Barr, Church & Lynch, 1999); in fact, when speech and gesture express different concepts, gestures are usually more reliable and more conceptually advanced (Church & Goldin-Meadow, 1986). Given the importance of gestures in teaching and learning settings, particularly mathematics and science environments, it is

surprising that the role of gestures in scientific and mathematical discourse remains largely unexplored in educational research (Lemke, 1998).

Gestures have been classified into different types including beats (or batons) and gestures of deictic (pointing), iconic, and metaphorical nature (McNeill, 1992). *Beats* are gestures that are void of propositional or topical content, and yet lend a temporal or emphatic structure to communication. Beats function as interactive gestures, which serve to regulate the coordination of speaking turns, to seek or request a response, or to acknowledge understanding (Bavelas et al., 1995). *Deictic* gestures are used in concrete or abstract pointing. They “point” out some aspect of the content, making it salient figure against everything else, which becomes rather diffuse ground. The accompanying utterance about this aspect is therefore “grounded” by means of a relation to the referent that is made salient by the deictic gesture. These gestures, thus, are context dependent. Deictic gestures, coupled with deictic utterances, play an important role during interaction because they establish a *distinction* between figure (topic) and ground (Hanks, 1992). In addition to pointing out features in the environment and indicating directions, they are also used to establish and maintain abstract spaces that become taken as shared so that speakers can make subsequent use of them without employing words (Haviland, 1993; Ochs, Gonzales, & Jacoby, 1996).

Gestures are called *iconic* when their shape is isomorphic with the content they convey (Lemke, 1999), that is, iconic gestures are hand/arm movements that bear a perceptual relation with concrete entities and events (McNeill, 1985). This

perceptual similarity constitutes their communicative strength because of a nearly transparent relationship to the idea they convey, particularly within a narrative event in which they depict co-present concrete objects and events (McNeill, 1992). The hands next to the temples with fingers configured such as to suggest horns while talking about a charging bull constitute an iconic gesture. *Metaphorical* gestures are like iconic gestures but provide a visual expression of abstract rather than concrete objects. A mathematician, whose left palm approaches the steady right palm in the context of talk about mathematical limits (e.g., in calculus), produces a metaphorical gesture for the idea “approaching a limit”.

In communicative encounters, speakers and listeners make available to each other many resources that provide contexts for constraining the meaning of utterances. Various kinds of movements with different parts of the body provide cues on how to understand just what is being said by limiting the range of possible figures to be isolated in a photograph. The body is so important to making sense in speech situations that there is a greater likelihood of communicative breakdown and need for conversational repair if visual access is barred (Goodwin, 1995; Egbert, 1996). During lectures that include inscriptions, gestures are important resources for the presenter to organize the alignment of talk and the visual representations (Goodwin, 1994). Gestures are important for sense-making processes, for when there are misalignments between features of the inscription, gesture, and speech, comprehension on the part of the audience is made more difficult (Roth & Bowen, 1999).

3.3. Study Design

To gain a better understanding of the relation between gestures and talk over and about photographs, I analyzed videotapes from a four-month seventh-grade ecology course, an entire second-year university ecology course (36 fifty-minute lectures), and a variety of lectures given by environmentalists about the watershed that they attempt to protect. In all these situations, the speakers made use of photographs that were visually available to the audience. There were contextual differences that allowed me to tease out the role of gestures. Thus, when the same biologist-environmentalist gave a lecture to the seventh-grade students, she used a variety of gestures. Giving a similar lecture with the same set of photographs to the scientists at a federal research institute, she presented in a darkened auditorium where she could not come near the projection screen and could hardly be seen herself. Finally, the professor in the second-year university course used an overhead projector to project transparencies against a screen. Here, his gestures were directed toward the transparency, yielding a different geometry between his arms, hands, and the projected photographs.

To conduct my analysis, I concentrated on one particular episode: a lesson about watersheds a biologist-environmentalist gave at a grade seven science class. I began my analysis by jointly viewing one of the videotapes together with my supervisor and another co-worker to conduct Interaction Analysis (Jordan & Henderson, 1995), an interdisciplinary, collective method to investigate the interaction

of human beings with each other and with the objects in their environment. These meetings were video-recorded allowing me to establish key elements for the quality of interpretive inquiry, “progressive subjectivity” concerning the categories that I developed and at the same time an “audit trail” (Guba & Lincoln, 1989). During the group meetings, videotape replay was stopped whenever someone thought a significant event had occurred; the event was reviewed as often as necessary so that each tentative assertion could be fully explored by all participants. In the absence of a substantial body of prior research, I began my analyses without predetermined analytic categories, developing them together as our group analysis evolved. As my comments and assertions evolved, so did my analytic approach. First, I noticed a need for a classification of the different gestures used to refer to the photographs during the lectures, as I identified the gestures as the most important semiotic resource available to the audience for interpreting the photographs in the context of a lecture.

To facilitate further analysis of the use of photographs in lecture situation, I therefore proceeded to a categorization of the gestures and body orientations that the speakers used in the different settings. This classification emerged through the attentive observation and further development of categories that had emerged during group analysis. Before I arrived at the categorization presented here, I went through a process of refining each category, by discussing all the examples of gestures provided in the videotapes, and by developing criteria to distinguish each one of the categories. I changed my classification until I had identified a set of exhaustive, non-overlapping functions of gesture/body orientations as meaning-making resources in talk over and

about photographs. My classification system covers the domain of gestures in my entire database.

Episodes were extracted from the videotapes for the constitution of vignettes that exemplify the categories; these episodes were imported into iMovie (a program supplied with Macintosh computers), which allowed me to play the video-clips at slower rates, to conduct frame-by-frame analyses, and to save individual frames for the production of still images. Still images were extracted to produce the visual representation of the gestures that would accompany each vignette that I produced for analytic purposes. The videotape was played through the computer monitor, and each significant frame pertaining to a specific gesture was isolated and then printed out. Subsequently, using a transparency, I produced drawings of the selected frames, highlighting only the relevant features for the representation of each category of gestures and body orientations. The drawings were scanned and inserted in my written analyses.

3.4. Gestures and Body Orientations: Constraining and Multiplying the Meaning of Photographs

The study of gestures and body orientations as meaning-making (semiotic) resources for understanding and learning from photographs is new to science education. I therefore begin by providing some principles of analysis that I developed as part of this work before moving to the description of the different functions that

gestures/body orientations have as semiotic resources to constrain and multiply the meaning of photographs used during lectures.

3.4.1. Principles of Analysis

Communication can be analyzed in terms of the dialectic relationship between imagery and language (McNeill, 2002). In the present situation, there are two modes of imagery—photographs and gestures—that constitute the counterpart to speech; together, imagery and language form a unit. Any unit that embodies simultaneously different but inseparable elements is a dialectic unit (Il'enkov, 1977). This means that there are inherent tensions between the text (written or verbal) and the imagery embodied in photographs and gestures. Lemke (1999) contrasted these two means of communication in terms of the difference between the typological nature of language and the topological nature of images and gestures. However, there is more to the imagery-language dialectic, for the speech and gesture are produced in the course of talk but photographs constitute something like a stable ground. Together, therefore, talk and gesture are also in a dialectical relation with the photograph—co-produced, they inform listeners about what might be found in the photograph. At the same time, the photograph may be treated as evidence for the existence of the phenomenon elaborated by the lecturer. The gestures co-occur with the text and are directed toward the photograph, providing anchors that integrate text, photograph, and gestures into a total performance.

The types and shape of gestures produced by a speaker also depends on body orientation (Haviland, 1993; Roth & Lawless, 2002). Body orientations, in fact, constitute interpretive frames for gestures limiting their interpretive flexibility and thereby enhancing and even multiplying the meaning of photographs. I therefore analyze all events in terms of gestures and body orientations.

Photographs generally lend themselves to a wide range of different interpretations. When making reference to a photograph, a lecturer can use different strategies to constrain the emergence of diverse interpretations that, though legitimate, are not suitable for the topic at issue. In a textbook or article, these strategies include the written text, the indexical reference to the photograph, the caption and, in exceptional cases, the use of arrows, highlighting, etc. on the photograph itself. These strategies limit but do not completely avoid the emergence of different interpretations of the photograph (Bastide, 1990). When a photograph is used in a lecture situation, however, the strategies used by the lecturer to constrain the occurrence of misinterpretations are different. Although the text still plays an important role in directing the audience towards the “right details” in the photograph, the ambiguity of the text implies the use of more explicit associations between text and photograph. In this context, the gestures/body orientations function not only as the reference to the photograph, but also as the means by which text and photograph are explicitly associated with each other. Through gestures, lecturers narrow the range of ways for looking at photographs. Thus, although most journalists and television audiences saw the Los Angeles police officers beat up Rodney King, Goodwin (1994) showed how a

police expert taught the judge and jury to view the video recordings as evidence for the contention that Rodney King was not “beat up” but “intelligently kept under control.” In my database, each specific instance of the talk was directly associated with a correspondent gesture/body orientation, which, in turn, guided the viewer through the photograph. That is, the lecturers guided their audiences through photographs not only by means of text but also by their deployment of gestures and body orientations.

What utterances lack in sophistication or specificity is provided by the gestures/body orientations directly associated with them, that is, the text which by itself could generate many doubts because of its ambiguous nature, is enhanced by the gestures, which complement the text. Both text and gestures together form a structure that becomes the lens through which the photograph is viewed. Although different interpretations may still arise, a photograph in a speech situation can have its interpretive horizon narrowed such that the opportunities for new and diverse interpretations are by and large reduced.

The body orientation is part of the periphery of the gestures that contextualizes the entity to be made salient in the photograph. Such changes in periphery can be perceived as a clue that allows the audience to move its attention away from the currently projected photograph and to focus on the relation between words and gestures alone. When a speaker stands between the audience and the screen onto which photographs are projected within reach of the speaker, one can distinguish two orientations. In the first, the speaker’s head and frequently shoulders and upper

body are oriented toward the photograph. This orientation signals that gestures and talk pertain to something visible in the photograph. In the second, the speaker is clearly oriented toward the audience. This body orientation signals that the current topic is about something not directly available in the photograph (Roth & Lawless, 2002).

When a photograph is used in a lecture situation where photograph and lecturer are visible to the audience, the body orientation therefore becomes a resource on which the audience can rely when interpreting the photograph in the context provided by the spoken text. The lecturer's body orientation helps to distinguish different types of gestures and provide resources for connecting verbal text and photograph, insofar as it provides cues to the audience about where to focus their attention, either on the photograph or on the lecturer. Each position or orientation the lecturer assumes represents a different phase of the speech, and the audience is provided with a resource for grasping that just by looking at the position of the speaker. When lecturers turned towards the photograph, their body orientations accounted for the same as if they had said, "now look at the photograph"; however, when they turned sideways or fully to the audience, turning their backs to the photograph, this was the same as saying, "now pay attention to me and my gestures but not the photograph." Lecturers do not have to say this in words, but indicate these attitudes by changing their body orientation.

3.4.2. Functions of Gesture and Body Positions

The gestures appeared as the most important semiotic resource that the audience could rely on to interpret the photographs in the course of a lecture. My classification of the gestures therefore helped me to investigate the pedagogical functions a photograph can achieve when it is used in a lecture situation as opposed to a textbook or journal situation. Describing each category of gestures allowed me to analyze the interactions between photograph, text and gestures that are associated with the work of interpreting and using photographs during lectures. I emphasize the function of each gesture in the working of interpreting the photographs and connecting them to the topic of the discourse, that is, the subject matter to be taught. To limit the amount of text required to explain the concepts of the different lectures analyzed, I took all my examples from one 15-minute lecture of the biologist-environmentalist who repeatedly assisted two seventh-grade teachers in the process of implementing a four-month environmental unit.

In the particular lecture chosen, the biologist-environmentalist attempted to teach the concept of “watershed” drawing on photographs, aerial photographs, and maps mounted as slides and projected against a screen covering the chalkboard. Throughout the presentation concerning the concept of watershed, the biologist-environmentalist stood next to and in front of the projection screen. She used many of the same photographs in other recorded lectures, including one that she gave to the scientists in a nearby federal research institute.

During my analysis, I classified the different functions that gestures/body orientations had in relation to the photographs when used by the different lecturers in

Table 3.1

Functions of gesture/body positions in the presence of photographs and speech

Function	Characteristics				N
	Gestured phenomena available in photo?	Deictic/iconic	Specific/generic	Body position	
Representing	No	Iconic	Generic	Towards the audience	30
Emphasizing	Yes	Iconic/deictic	Generic	Towards the photograph	20
Highlighting	Yes	Deictic	Generic	Towards the photograph	12
Pointing	Yes	Deictic	Specific	Towards the photograph	11
Outlining	Yes	Deictic/iconic	Specific	Towards the photograph	8
Adding	No	Iconic	Specific	Towards the photograph	6
Extending	No	Deictic	Specific	Towards the photograph	3
Positioning	No	Iconic	Generic	Towards the photograph	2

my database. My classification includes eight different functions of gestures/body orientations produced as semiotic resources for making sense of photographs: (1) Representing, (2) emphasizing, (3) highlighting, (4) pointing, (5) outlining, (6) adding, (7) extending, and (8) positioning (Table 3.1). In this classification, I take into account the position of speakers when they gesture, the relation of the gesture with the photograph (e.g., if the photograph is used as a background for the gesture or not), the visual availability of the object/phenomenon in the photograph, and the primary function of the gesture in relation to speech and photograph. I distinguish the production of gestures along the following lines: gestures are deictic, iconic, or both; they can be distinguished as specific or generic; they present a phenomenon that is or is not available in the photograph; and body orientation (Table 3.1). The total number of gestures in the 15-minute lecture about watershed was $N = 92$; in Table 3.1, I provide frequency data for this particular lecture.

3.4.2.1. Representing

The gestures classified in this category were those speakers used to represent objects or phenomena not directly available in the photograph and yet associated with some feature of it. Although utterances were related to the photograph, the gestures were about something not directly visible in the photograph such as a gesture enacting the downward slope of a road seen on the projected aerial photograph (Figure 3.2). These gestures were iconic, resembling the shape or the movement of something real, familiar to the audience. They were also generic because they referred to slope in general rather than portraying the specific slope of the road in question. When using such gestures, the speaker was always (100%) oriented such that the speaker's regard fell somewhere between paralleling the projection screen to facing the audience (making 25% of all possible body orientations). This type of gesture/body orientation was the most frequent in the watershed lesson analyzed. In the entire presentation, 30 representing gestures were recorded.

Figure 3.2 presents an example from the category of *representing*. In this sequence, the speaker represented the downward slope in the road previously pointed out by another type of gesture. Her body was turned halfway to the audience, shifting position as she started talking about a sloping hill that was not represented in the aerial photograph. The speaker looked at the audience as she uttered and gestured, providing a noticeable frame directing attention away from the photograph and to the gestural resources.

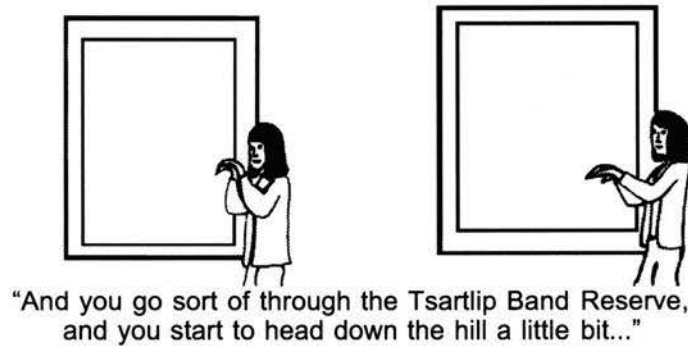
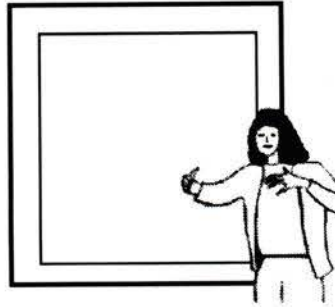


Figure 3.2. Example of *representing* category of gestures. The photograph does not contain the feature represented in the gesture. The speaker turns the head toward the audience, but remains sideways so that the downward motion of hand/arms remains visible. The gesture is iconic and generic.

These gestures, therefore, not only provided resources to focus attention, shifting from photograph/speaker to speaker alone at the moment that the audience is expected to do so, but they also help to understand the topic of the discourse, insofar as they represent something not visually available or available in another way. That is, in the present situation, the audience could see in the photograph a bird’s eye view of road winding its way from the village along the coast and toward the creek that defined the watershed. The speaker’s gestures provided a means for students to connect to their experience of driving along this road; that is, the gestures constitute an iconic, concretely embodied representation of driving along the road that was not perceptually available to the audience only by means of the aerial photograph. The gestures opened up a third dimension in the photograph and connect it to the discourse and the real world the photograph partially represents.

The topic of the lesson from which I extracted the examples of the different categories of gestures, was the concept of watershed. In this context, the lecturer’s



“So this is basically a drainage area that is collecting the water that falls on the lands.”

Figure 3.3. Example of *representing category* of gestures. The speaker completely turns toward the audience and provides a visible image of the basin that constitutes a watershed that drains into a creek; the phenomenon is not directly available in the aerial photograph. The gesture is iconic, representing the heights of land, and generic, representing types rather than specific heights.

representational gestures have the potential to help students define a watershed. The road followed a downhill slope towards the creek that gathered all water in the area; in fact, the road crossed the creek only two hundred meters from where the latter shed into the inlet. The gestures were used to provide a visual image of the downhill slope, which the photograph by its nature could not depict. Similarly, when the lecturer bent her arms, forming a circle parallel to the floor, at the same time referring to a watershed, the audience is able to associate visual and verbal resources to define a watershed as a delimited area (Figure 3.3). In another situation, she used the same gesture but then moved both arms downward until they met and then meandered to suggest the creek flowing into the ocean inlet.

3.4.2.2. Emphasizing



"Graham is coming up this way and
Hagan is coming down this way."

Figure 3.4. Example of an *emphasizing* gesture: The referent entity is available in the photograph, the gesture is generic and iconic/deictic, and the body orientation toward the photograph.

In this category, I counted iconic gestures that emphasize an entity directly available in the photograph, by generically following the shape/movement/direction of the object/phenomenon referred to in speech; the gesture therefore also had deictic function. When speakers gestured in such cases, they were positioned towards the photograph (shoulders somewhere between parallel to the audience's line of sight and parallel to projected image) and the gestured phenomenon was available in the photograph. Here, too, the speaker's orientation therefore functioned as a frame orienting the audience to look at the relation between gesture and corresponding features in the photograph. There were 20 emphasizing gestures produced during the presentation on the watershed concept.

In Figure 3.4, for example, the gestures emphasized the confluence of two creeks (Graham, Hagan), and how they come together at some point. The background for this gesture is an aerial photograph, and, although the speaker was not specifically tracing the creeks in the photograph, she approximately represented the direction of

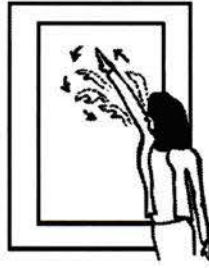
those creeks as they were perceptually available in the photograph. The gesture is iconic, for there were two creeks that came together at about the area she gestured; the gesture was generic in that neither right nor left hand arms paralleled the creeks; and the gesture was deictic, for it allowed the students to look in a particular direction for finding the referent of the gesture. A similar two-armed gesture (e.g., Figure 3.3) produced in the context of an orientation towards the audience signified the “heights of land that define and delimit the watershed.” These heights of land, in contrast to the creek, were not visible in the projected image, a fact clearly signaled in the corresponding body orientation. This second instance, therefore, despite its perceptual similarity to the gesture in Figure 3.4, was a representing gesture.

Central to understanding the concept of a watershed is the idea that all water falling within its confines is carried away through a river system that sheds at one location into the ocean. A watershed is a drainage basin common to a particular area, defined by “the heights of land.” Figure 3.4 clearly shows that the gesture does work in emphasizing the common direction that two different creeks in the system are taking. After pointing out the two creeks sequentially, the double-arm gesture simultaneously represents the two creeks and their confluence, which emphasizes the aspect of a watershed as a drainage basin. When she turned away from the photograph and rotated the double-armed gesture into the horizontal direction, the same gesture represented the “heights of the land” from where the water flowed and represented the two creeks that meandered (meandering motion of hands joined at palms) downwards to the ocean. This downward flow of water in a watershed was not visually available

in the photograph, thus the rotation away from it. They become perceptually available, however, through the representational gestures. The gestures here add the ideas of downward flow and the idea of motion, and therefore link the static photograph to a dynamic phenomenon.

3.4.3.3. Highlighting

Highlighting gestures are deictic but have a generic shape; they usually are circular or elliptical in shape without having clearly determined boundaries. These gestures are used to focus attention to the approximate area where something was to be found; the orientation is therefore toward the photograph. For example, while introducing students to an aerial photograph of the watershed that also included their school and village, the speaker used these gestures to direct attention to different but not well-defined areas that she wanted students to identify, such as the mountain that dominates the valley. Because there are no determined boundaries, it is harder to identify the object completely; the circular gesture (e.g., Figure 3.5) simply directs the viewer's attention to some area in the photograph, but there are no details available that would assist the audience in identifying the specific feature to be attended to. It is therefore not surprising that it took several increasingly concrete prompts before the students provided the name of the entity (mountain, quarry) that the speaker wanted them to identify. I counted 12 highlighting gestures during the mini-lesson on watersheds (Table 3.1).



“And so up here, any idea [what this is]?”

Figure 3.5. Example of *highlighting*. The gesture is deictic, pointing to something, but generic because the outline of the thing is not specifically identified. The orientation is toward the photograph.

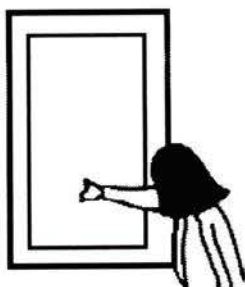
I consider these gestures as a special type of deictic gestures, insofar as they point out something in the photograph, but in a very general way, without clearly identifying boundaries as *outlining* gestures (see below) do. In this sense, they are deictic gestures that highlight something in generic fashion instead of specifically pointing to something in the photograph.

Photographs are inherently full of details many of which are not relevant to the main features; this increases the difficulty in selecting just what is to be seen in the photograph is apparent in the present case when students named features other than the mountain that the speaker wanted to make salient. There are almost endless possibilities of interpretation of the same photograph. The text narrows these possibilities and gives the audience guidance towards the “right details” in the photograph. In a textbook, caption and body present the relevant text. In a lecture, the text is provided by verbal utterances; gestures and body orientation of the lecturer constitute additional semiotic resources available to the audience that in fact will help

them to distinguish background and foreground in the photograph and choose the right details as the relevant ones in any given context. When highlighting the mountain in the photograph, the speaker directs the attention of the audience to an essential object in the photograph, one that is crucial to understanding the concept of watershed. A watershed is delimited by the heights of the land, and in this particular watershed, the mountain in the photograph is part of the boundary that defines the watershed within which the students' village and school lies. Therefore, identifying this object in the photograph, even if only in generic fashion, is an important part of the lesson and highlighting gestures assisted, though could not entirely disambiguate, the nature of the watershed boundary.

3.4.2.4. Pointing

Pointing gestures belong to the class of deictic gestures. During the lectures analyzed, speakers pointed to specific objects in the photograph, or, in some instances, to the entire photograph. Pointing is very specific, towards an object in the photograph that is clearly defined (at least to the speaker). It is also frequently accompanied by deictic terms such as “this,” “that,” or “here.” The objects in this situation are always visually available, that is, the action of pointing requires the availability of the object in order for the audience to understand. This characteristic of the object—its visual availability—is the most important one in order to distinguish between what is considered a pointing and what is considered an extending, according



“And your school would be right here.”

Figure 3.6. Example of *pointing*. The gesture is specific and deictic and associated with a body orientation towards the photograph.

to my classification. In the lesson about watersheds, there were eleven pointing gestures.

In Figure 3.6, for example, when the speaker pointed to the photograph and said, “right here,” she did more than just pointing. That is, the students had available not only an index for finding their school in the photograph, but also an indication of the boundaries of this object, its extension—it is small in comparison to the entire photograph or extended objects such as the mountain in Figure 3.5. When the extensions of the entity are small, students can easily identify what is being pointed out. The gesture brings the exact location of the school in the aerial photograph to the foreground, leaving everything else in the background.

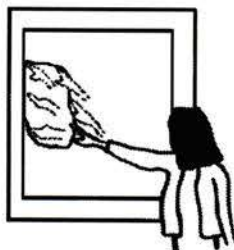
These gestures are distinguished from the previous category (highlighting) because of their specificity; that is, pointing implies a very specific object or phenomenon in the photograph, while highlighting is a more general gesture, pointing out something not entirely delimited in the photograph. In this situation the possibilities of different interpretations of the photograph are narrowed such that

only one interpretation is probable, namely that intended by the speaker. As long as the audience is able to see what the lecturer is pointing to in the photograph, the connection of text and photograph is immediate. However, when the entity to be referred extends in space, a simple pointing gesture is insufficient as it could refer both to the entity and one of its parts (which a novice could in fact interpret to be the entity). In this situation, outlining gestures provide meaning-making resources to the students.

3.4.2.5. Outlining

Outlining gestures are very specific deictic gestures often used to follow the shape of some entity in the photograph; because over time the gesture traces out a shape (nearly) identical to the object, it is also iconic. In outlining gestures, the speaker always makes use of the photograph, which the audience, assisted by the gesture, is expected to divide into figure and ground. The shape of this gesture depends on the visual availability of the object in the photograph insofar as that what is outlined is something in the photograph, visually available to the speaker and to be identified by the audience. In the talk about the watershed concept, there were eight gestures that outlined an entity in a photograph.

Figure 3.7 exemplifies the outlining of a specific area in the photograph. As expected, the speaker is directed towards the photograph, carefully following the shape of the coastline, thereby defining the boundary of the inlet into which the watershed empties. Both her gestures and the referent object (Saanich Inlet) are visible



“So this would be Saanich Inlet over here.”

Figure 3.7. In this example of *outlining*, the speaker used her index finger to follow the coastline that defined the ocean inlet: the gesture is specific, deictic-iconic and the body orientation is toward the photograph.

from the audience’s perspective. Because of the close spatial relation between the moving pointer (finger), the possibilities of mistaking the coastline and with it “Saanich Inlet” for something else are greatly narrowed and the identification of the relevant details in the photograph is immediate. In following the coastline and thereby in outlining the inlet in the aerial photograph, the lecturer provides a resource for students to guide their attempts of connecting the photograph with their lived and experienced world, their neighborhood. In doing so, the speaker provided a concrete part of the complete system that defines a watershed. The gestures constituted important resources in isolating the concrete case of a whole watershed or its parts from the interpretively under-specified photograph.

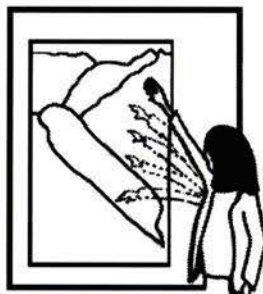
3.4.2.6. Adding

Adding gestures were also used to outline entities, but, in this case, the object/phenomenon was not visually available in the photograph but that *could have*

been there. The gestures provided another layer of specific perceptual objects that were created in iconic form in front of the photograph but were to be understood as an addition. Gestures that added something to a photograph occurred six times in the watershed lesson.

Consider for instance Figure 3.8. In this example, the speaker modeled a phenomenon, “an oil spill in the heights of the land,” as it would unfold in the area represented in the photograph. As she talked about a potential oil spill, she traced what would be the results of this hypothetical phenomenon in the photograph, that is, the oil flowing down into the creeks and subsequently into the lake. Although neither the creek nor the phenomenon of an oil spill can be seen in the photograph, the speaker “drew” another, virtual image of oil flowing down into the creeks and into the lake. The situation is hypothetical—but the gestures rendered this event concrete. The speaker added something, literally layered it onto the photograph, in a way that only her gestures could make it perceptually available to the audience. This is a completely new meaning-making resource for understanding photographs not achievable in a textbook. The gestures can be understood as a form of concrete, public, and witnessable thinking.

In this example, the presenter emphasized a particular feature of a watershed, that is, the idea of a watershed being a drainage area that is delimited by the heights of the land and providing the topology defining water flow. By adding a new event using the photograph as a background, a direct association was established between the photograph and the idea of a watershed, as well as the consequences of pollution to a



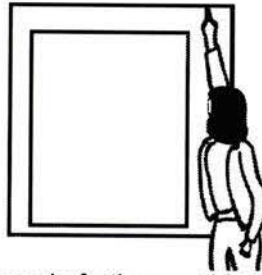
“Say something happened up in the heights of the land, the headwater of that area, like an oil spill. You would ultimately be able to trace the impact of an oil spill up in the top, all the way through the creeks, and its impact right down in to this lake here.”

Figure 3.8. Example of gestures that add something in the photograph. The gesture is specific/generic and iconic/deictic, associated with a body orientation toward the inscription.

watershed; this pollution would not just remain where it occurred but by moving in the way the gestures showed, would have an effect on the entire system. The lecturer here was able not only to associate photograph and speech for defining a watershed, but also she amplified the photograph as if it was showing an event.

3.4.2.7. Extending

Extending gestures are specific deictic gestures used to add something to the photograph that does not fall within its boundaries. That is, the entity referred to is located outside the limits of the photograph, so that, if the photograph were taken from a greater distance, the entity would have been included; consequently, the body orientation was toward the photograph. In this sense, the chalkboard, the wall, and anything that surrounds the photograph becomes an extension of it, insofar as the speaker pointed out something in these areas, outside the photograph. Because the gesture is intended to add something beyond the boundaries of the photograph, the



“Sidney is further up this way.”

Figure 3.9. Example of gestures that extend the photograph, pointing at something specific somewhere off the photograph and therefore not directly available but that would have been visible if the photograph represented a larger area; consequently, the body orientation is toward the photograph. The gesture is specific and deictic.

speaker orientation is, consistently, toward the representation (Figure 3.9). In the watershed presentation, these gestures were observed three times.

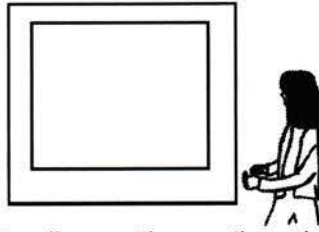
As with the adding gestures, the audience in this case is also invited to imagine something not visually available in the photograph. The gestures connect the photograph, as a representation of something real, to the actual real world, extending the boundaries of the photograph to include other aspects. Talk and gestures are again a means by which the lecturer can transform the photograph as to show to the audience something that is actually not visually available just by looking at it. It is almost as if the photograph was a different photograph; the lecturer points to objects that are outside of the photograph just beyond of its boundaries and yet as if represented on the (extended) screen. The audience is invited to follow her through her gestures and speech to envision the aerial photograph as covering a little more area.

The relevant function of this gesture to the effort of defining a watershed is the fact that the lecturer can introduce additional elements that assist the audience in understanding the concept or the location of the photograph with respect to the larger setting known to the audience.

3.4.2.8. Positioning

This type of gesture, specific/generic and iconic is strongly related to body orientation, constitutes another type of extension, but this time into three-dimensional space. Speakers positioned themselves against the photograph as if they were actually taking the shot at that exact moment, standing in the landscape depicted. Speakers therefore allow the audience, through their body orientation, to understand the photograph as if it was extended into the lived space to produce a three-dimensional image. There were two examples of positioning in the lesson analyzed, both in the context of landscape photographs.

Figure 3.10 provides an example of positioning. The resulting representation goes one step further than any photograph—through its association and placement relative to the speaker it makes the photograph an extension of the watershed into the classroom allowing the speaker's actual movement to become movements in the watershed. The speaker in fact takes up a position in a hybrid world that instantiates the watershed in the classroom. Positioning works as an explanation, an introduction to the photograph itself and the topic related to it. The lecturer introduced the photograph to the audience as a depiction of the real world, making a direct connection



“So, we are standing on the southern boundary here.”

Figure 3.10. Example of *positioning*, an specific/generic gesture of iconic type that, together with the body position, virtually extended the photograph into three-dimensional space.

between photograph and real world in showing how and from what angle the photograph was taken. By doing this, she also made explicit the role of the photographer in the production of the photograph, exposing the human interference in this process that could otherwise be regarded as an essentially objective representation of the world.

The introduction of the photograph to the audience provides resources for looking at the photograph in a particular way, and it is very important for the work of interpretation of the photograph that will eventually follow. In this particular case (Figure 3.10) the lecturer was trying to identify the boundaries of another watershed, where the heights of the land that define the area are more difficult to be identified in the photograph. Therefore, she positioned herself to simulate where and how the photograph was taken so the audience would be able to recognize the photograph as a depiction of an area they are familiar with. She subsequently showed how the creek flows, first in a direction perpendicular to and approaches the areas seen in the photograph, then turning and flowing parallel to the screen toward the ocean on the left (from the audience). It is immediately evident that there were no examples of

positioning when speakers talked about similar photographs but did not stand near the projected image (e.g., the biology professor using transparencies or the environmentalist lecturing in a darkened hall).

3.5. Discussion

School science relies heavily on inscriptions such as photographs as pedagogical elements in teaching facts and concepts; they are the most frequent inscriptions in secondary-level biology textbooks. Whereas the previous study showed the limited number of meaning-making (semiotic) resources available to high school students when facing photographs in Brazilian textbooks, the present study shows how hand gestures and body orientations provide additional semiotic resources that teachers/lecturers can make available to assist students in making sense of photographs and the new concepts that they pictorially render. These gestures and body orientations play an important role in understanding just what students are to attend to in a photograph, whose meanings are inherently under-specified.

Understanding the relationships between talk, gestures, and photographs in science lectures therefore should be an important consideration in developing pedagogy related to the use of photographs in science education.

3.5.1. Constraining, Amplifying, and Multiplying Meaning in Science Lessons

For the situation where teachers/lecturers stood next to the photographs projected onto a screen in a room where they and the gestures were clearly visible, I

identified eight categories of gestures. These are distinguished by the function they have in relation to the photograph I exemplified these categories in the context of part of a talk concerning the concept of “watershed” presented by a biologist-environmentalist to an audience of seventh-grade students and their teachers. These categories include representing, emphasizing, highlighting, pointing, outlining, adding, extending, and positioning. All eight types constitute important resources that are deployed in addition to verbal discourse for understanding photographs, their contents, and their relevance to the theoretical concepts to be learned. They do multiple duties by limiting, amplifying, and multiplying meaning.

These eight types of gesture/body orientation combination constitute a range of semiotic resources not normally made available in textbooks. It is possible that written texts could provide suitable textual information to do what gesture and body orientation do. But identifying a specific object in a photograph by means of a written text would require a very descriptive and detailed text to generate a similar explicitness of the relation between text and photograph. The written text would become much more complex, and, yet, would not be able to guarantee that the relation between text and photograph will be appropriately established by the reader. My previous research had shown that there are many features that make it difficult to understand photographs in the way they are deployed in textbooks. With present technology—photocopying, scanning—teachers could actually project textbook images and, deploying relevant gestures/body positions, could assist students in picking out relevant detail to assist them in meaning-making processes. This would

make the highly text-oriented way of teaching science to include other modes of representing facts and concepts, including photographs and gestures. Future research should be designed to study whether students' competencies in interpreting and learning from photographs increase when they are exposed to whole-class presentations and readings of photographs where the teacher uses gestures and body orientation explicitly as additional resources for making salient or adding features.

As additional semiotic resources, gestures/body positions take advantage of the fact that they are of a different kind than text. If a textbook were to use the words "here" and "there," these would be far more difficult to understand than if a speaker who used gestures. These indexical words imply a specificity that cannot be achieved by the text, at least not in the same way in which it is implemented by gestures in the speech situation. Not only the photograph itself would have to have additional signs that would delimit the object of interest but also the text would have to be more detailed and descriptive to identify this object in the photograph. Gestures and body orientation are of a different kind than written and pictorial resources and, by their very nature, can be "layered" onto the photographs without nevertheless encumbering the auditory information channel. That is, because gesture and body orientation are of a different kind they can be apprehended without requiring additional attention resources.

In a speech situation, the "periphery" (Brown & Duguid, 1992) of the text is enlarged by gestures and body orientations, allowing the use of fewer words in a less structured way, and still being able to articulate the same message; the different

semiotic resources *multiply* meaning because, in some sense, they include a certain level of redundancy in and synergy of the different modalities (Lemke, 1998).

Classrooms where the gestural modality become available to teachers (and students) in addition to photographs and texts therefore implement some of the recommendations educational psychologists have made with respect to the need to use multiple representations of the same concept (Snow, 1997); gestures and body positions are a means that make classroom teaching inherently adaptive to the representational needs of students.

Much of the simplicity of the verbal text is due to the presence of the gestures that accompany the discourse. The gestures also function as part of the text (discourse), as a resource that simultaneously simplifies and amplifies the text, and consequently, enhances the explicitness of the connection between text and image. The gestures and body orientations that accompany speech and are directly related to the photographs allow the verbal text to be simpler and yet more specific and constrained in meaning than the written text. That is why, in some instances, one can expect students with difficulties understanding concepts in the book to more easily understand the same concept when the teacher (or someone else) provides them with a very similar explanation.

3.5.2. Role of Spatial Configuration

There is evidence that classroom discourse changes in fundamental ways when gesture and body orientation become available as resources to teachers and students

alike because the spatial configuration allows speakers to stand next to the artifacts and inscriptions (Roth, McGinn, Woszczyzna, & Boutonné, 1999). When speakers do not stand next to the artifact or inscription, the communicated content becomes more limited and the audience understands less. Thus, spatial configurations that do not allow the deployment of gestures and body positions to complementing speech decrease the number of meaning-making resources and become similar to those available for understanding photographs in textbooks. For instance, consider the differences in two situations when an ecologist talks about watersheds first in a classroom where her gestures and body orientation were visually available to the audience and then in a dark auditorium, where the audience could only listen to her and look at the photographs projected in the wall. In these two different lecture situations, the role of the photographs and the discourse itself changed drastically. When the gestures were visually available to the audience, the text was simpler and more specifically directed towards the photographs; the photograph became the topic of the discourse, and its pedagogical function in helping to understand the scientific concept presented was enhanced. However, when the gestures were not visually available to the audience, as for example, when the environmentalist was speaking in a darkened lecture hall, the details pertaining to the photographs but which were not visible to the audience could not be made available in the same way that the same environmentalist had done in the examples provided here.

When lecturers use transparencies, the gestures are made toward the transparency, and, although they function to highlight some aspects of what can be

seen in the photograph on the transparency, the lecturer's body orientation, as well as all the other types of gestures that do not use the photograph as a background, are absent from the audience's view. Therefore, the audience members have to attend to what is being projected on the wall without other semiotic resources being available in the case of talk next to the projected image. The fact that the room must be dark, with the lecturer gesturing on the transparency instead of on the projected image on the wall, further contributes to the distancing of the audience from the lecturer and separating him or her from the photograph. In this case, the gestures that do not make use of the photographs as a background and that are in other circumstances important resources to facilitate the interpretation of the photograph are not available. The same types of gestures are not used, or if used, are not visually available to the audience, limiting what could be learned from photographs had the additional semiotic resources been available as a pedagogical means. That is, the importance of a photograph as a pedagogical resource in a lecture situation is greatly increased when the audience is able to see both photograph and lecturer at the same time, and when the lecturer gestures over and about the photographs, thus exploring the photograph in its full potential. In the potential chaos arising from the proliferation of new ways of talking that students may experience in lectures, in which the same words are often used to denote different objects, gestures and body orientations are crucial resources to establishing a coherence that allows audience to appropriately connect photograph and text, being able to understand what is being talked about. Gestures, therefore, play an important role in science discourses, and should be more carefully investigated.

Chapter IV

Making Sense of Photographs

Abstract

In some contexts, a photograph may be worth a thousand words; on its own, however, a photograph means little because it underdetermines its interpretation giving rise to many different ways of seeing and understanding it. The purpose of this study is to investigate how high school students understand photographs that were accompanied by different amounts and types of co-text (caption, main text). The data for this study consists of video-recorded interviews with twelve Brazilian high school students. What students perceive is in part a function of the presence of caption and main text, which therefore not only describe what can be seen but also constitute a pedagogy for looking at photographs. I conclude that high schools not only develop subject matter literacy but also a literacy concerning photographs.

4.1. Introduction

Every image embodies a way of seeing. Even a photograph. For photographs are not, as is often assumed, a mechanical record. Every time we look at a photograph, we are aware, however slightly, of the photographer selecting that sight from an infinity of other possible sights. This is true even in the most casual family snapshot. The photographer's way of seeing is reflected in his choice of subject. ... Yet, although every image embodies a way of seeing, our perception or appreciation of an image depends also upon our own way of seeing. (Berger, 1972, p. 10)

We live in a visual world. Television, movies, and photographs are pervasive, constantly overwhelming us with images of reality in places other than where we are finding ourselves. It is therefore not surprising that photographs are also the most frequent type of inscription (representations other than language) in high school biology textbooks (Roth, Bowen, & McGinn, 1999). Existing research suggests that pictures have the potential to make significant contributions to textbooks, particularly because retention of text appears to be improved by such illustrations (Peeck, 1993). Yet there is very little research investigating the pedagogical role of photographs in school science: neither the psychology of cognition and learning nor science education research have paid much attention to this topic (Schnotz, Picard, & Hron, 1993). What complicates the issue is that photographs may be worth a thousand words, but on their own, they mean very little (Wittgenstein, 1994/58). They give rise to innumerable, different interpretations because, as the introductory quote articulates, their meaning emerges from a transaction of the photographer's way of seeing and the perception of the reader. It is the reader's work of reading, the viewer's perception of

the narrative and perceptual order of the photographic image and the surrounding text, and the meaning-making resources available to the reader that allows a specific interpretation of a photograph to emerge (Bjelic, 1992). The question therefore arises what high school students will perceive when they look at photographic images in biology textbooks and how they use other meaning-making resources that the text makes available to come to an understanding of the things that the photograph is about. The purpose of this study is therefore to find out how high school students understand photographs that are accompanied by different amounts and types of co-text (caption, main text).

4.2. Background

Traditionally, textbooks have been important resources in students' learning because most science classes are oriented toward these resources. In fact, school science is dominated by textbooks-oriented approaches to teaching and learning (NAS, 1997). Because these textbooks predominantly use photographs and naturalistic drawings (Roth *et al.*, 1999), photographs therefore ought to attract science educators' attention so that their potential as meaning-making resource can be more fully developed.

An increasing number of studies document the important role of representation practices in science (e.g., Knorr-Cetina & Amann, 1990; Latour, 1999; Lynch & Woolgar, 1990). However, despite the centrality of representation practices in science and despite the many open questions as to the role of inscriptions such as

photographs in instruction, relatively little research has been conducted in science education (Roth & McGinn, 1998). Outside science education, a small number of studies considered the role of photographs in communication (Livingston, 1995). These studies confirm the statement in the introductory quote that photographs are often taken as mechanical records of reality; they are thought of as being automatically produced, “a recording furnished by an apparatus that offers the reader a guarantee against the intervention of the author” (Bastide, 1990, p. 206). Photographs are therefore taken to be prima-facie evidence, that is, as guarantor of truthful representation (Myers, 1990). All of these underlying assumptions are based on the similitude of photographs with the objects they represented. But even such similitude is a cultural and individual achievement and cannot be taken a priori (Eco, 1984). The photographs can only achieve their powerful role as representations of the real world through the reader’s work of interpretation, the viewer’s perception of the narrative and perceptual order of the document (Morrison, 1989). The purpose of this study is to understand this work when the readers are high school students, and the photographs and associated text are from high school textbooks that are widely used by schools in Brazil.

How inscriptions are deployed in textbooks plays an important role in the lived experience of students and in their associated appropriation of image-reading practices in the course of schooling. But there is an ambivalence concerning images in textbooks (Schnotz, 1993). On the one hand, teachers and curriculum designers believe

that images have a lot of potential as meaning-making resources; yet in use, images are often used as adjuncts that serve decorative purposes. On the other hand, students prefer textbooks that contain illustrations; yet in learning, they pay only little attention to them. We therefore need a better understanding how students use photographs, how they can use them in their meaning-making efforts, and, ultimately, how teachers can assist students in learning by drawing support from images.

Most students are indeed familiar with photographs in general; however, appropriate instructions for how to read and analyze photographs are currently not provided to them. To understand the effect of photographs in learning, one must consider not only the way they are produced, but also the way they are received by the reader. This study is therefore concerned with the way in which students interpret and make sense of photographs and their associated texts in the context of a scientific concept presented in a textbook. I analyze the meaning-making resources that students discover and draw on while looking at images and associated texts, and how the students make use of these resources to achieve understanding.

4.3. Study Design

This study is concerned with understanding the pedagogical function of photographs in school science textbooks. In the two previous chapters I provided analyses of the meaning-making resources that texts and lectures provide in support of the pedagogical function of photographs in school science. These previous studies did not address how students understand photographs and which meaning-making

resources they actually would draw on in their interpretative efforts. In this study I therefore interviewed students from different grade levels, showing them photographs from biology textbooks and asking them to articulate what the photographs meant to them. I extracted the photographs from the ecology-related chapters of Brazilian high school biology textbooks that had been analyzed and categorized in chapter 2.

4.3.1. Selecting the Students

To investigate photographs and their relation to captions and main text during interpretation, students from two distinct groups were interviewed: (a) students who did not have an ecology course at the high school level and (b) students who already studied ecology as part of their compulsory high school biology course. This choice should allow me to determine the role of prior knowledge on the interpretation and comprehension of photographs and associated texts. In most of Brazilian schools, primary education includes grades K through 8, and high school includes grades 9 through 11. Basic notions of ecology are usually taught in two general science courses that students attend in grade five or six. An expanded ecology curriculum is taught as part of the biology curriculum while students attend grade ten or eleven, depending on the school.

A total of twelve students, six from each of the two groups were interviewed. I invited students during one of their courses and students were selected on a first-come-first serve basis. In this way, the first participant group included five grade nine

students, three females and two males, and one grade eight male student. The group of students who have had prior instruction in ecology consisted of five eleventh-grade students, four males and one female, and one tenth-grade female student. Pseudonyms are used throughout this study. All interviews were video-recorded.

4.3.2. Selecting the Photographs

Among the various photographs displayed in the ecology-related chapters of high school biology textbooks, four photographs were selected. Based on the results of my previous study presented in Chapter 2, I concluded that the four photographs were representative of different categories of photographs. The following aspects were addressed in the selection of the photographs: (a) the opposition between single and multiple photographs; (b) the differences between the four major categories (based on their function) of photographs (decorative, illustrative, explanatory, and complementary); and (c) the presence or absence of the indexical reference to the photograph in the text (i.e., incidence and placement of a sign such as “Fig. 30.3” in the text). I began by selecting a variety of photographs that could address one or more of these aspects; I then analyzed each photograph, which led me to further refine this selection until I was satisfied with four photographs as meeting the three aspects.

The first photograph I choose—the photograph of the orchid (Figure 4.1)—represents a single photograph, categorized as *illustrative*. This photograph presents a caption and a main text associated to it and an indexical reference appropriately placed

Inquilinism

It is an inter-specific harmonic association, in which only one species is benefited; nevertheless the beneficiary does not cause prejudices to the other associated species.

The *tenant* (beneficiary species), gets shelter (protection) or even support in the body of the host species. It is the case of the interaction between orchids and bromeliads and the trees in which trunk they are installed (figure 83.1). The orchids and bromeliads, differently than what some people believe, are not parasites, since they do not cause any kind of damage to the host plants.

They have adapted to live in the top of the trees, where they find ideal conditions of luminosity for their development. Therefore, they are called epiphytes (epi: above); this kind of inquilinism is also known as *epiphytism*.



Fig. 83.1– Epiphyte plant.

Figure 4.1- Photograph of the orchid. Reproduction of the main text and the photograph with caption, as they originally appear in the textbook. In the original, the text was in Portuguese and the photograph in color.

in the main text. In chapter 2, I had identified some issues related to this photograph that could generate doubts and misinterpretations, due to the enormous amount of details present in the photograph, and the lack of information in the caption as well as in the photograph itself that could otherwise have helped the readers in the work of interpreting this photograph.

The second photograph exemplifies the category of *decorative* illustration (Figure 4.2); it lacks caption and indexical reference in the text, which makes it difficult

CHAPTER 2

ENERGY AND MATTER IN THE BIOPHESRE

**What this chapter is about**

A great contribution of Ecology to the contemporary thought is to call attention to the intricate network of relations that exists between living beings and the environment. The human species, besides being part of this network, has caused a great impact on it. To know basic concepts of Ecology is indispensable to everyone who wishes to be conscious and responsible citizens.

Highlights

- The organizational levels that constitute the biosphere: ecosystems, communities and populations.
- The relations that exist between autotrophs and heterotrophs and their importance to the perpetuation of life.
- The structure of food chains and webs, and the role of producers, consumers and decomposers in the ecosystems.
- The pyramids of energy and biomass that illustrate the behavior of matter and energy in the biosphere.
- The cycles of the most important chemical elements that are essential to living beings: cycles of carbon, oxygen and nitrogen.

Figure 4.2- Photograph of the caterpillar. Reproduction of the entire page of the textbook where this photograph originally appears. In the original, the text was in Portuguese and the photograph in color.

to relate it to any specific text. For the interview, I reproduced the entire page where this photograph appears, leaving it to the participants to decide whether the text pertains to the photograph. Decorative photographs primarily enhance the aesthetic aspects of the textbook and may attract the reader's attention. The chosen photograph shows a caterpillar.

The third item consists of a series of three photographs, previously categorized as complementary, dealing with the concept of camouflage (Figure 4.3).

Camouflage and mimicry

Among many kinds of adaptation, deserve highlight those that make individuals of one species become less visible and blend themselves with some things in the environment or even make themselves similar to living beings of different species. With such abilities, these individuals can hunt their preys more easily or, differently, escape from the attack of their natural enemies. These kinds of adaptation are called camouflage and mimicry.

Many insects, reptiles, amphibians and birds have green color and, thus, they make a perfect camouflage among the leaves where they hide in. Among insects, some has acquired, during the evolution, color and shape of aculeo (the false thorn of roses). These insects try to have advantage with this adaptation living among plants that have aculeos.



Fig. 577. The European partridge, during the winter, shows white plumage, blending with the snow. At the end of the winter, it starts to change its plumage, and acquires a coloration that blends with the dry vegetation where it lives. This is a good example of **camouflage**.

Figure 4.3- Photographs of camouflage. Reproduction of the main text and the photographs with caption, as they originally appear in the textbook. In the original, the text was in Portuguese and the photographs in color.

These multiple photographs have a caption and a main text associated to it, although they lack an indexical reference in the text.

The fourth and final photograph (Figure 4.4) is another single photograph, presenting a caption that is appropriately associated with the main text by means of an indexical reference. The topic of the text is mutualism, and the photograph presents lichens as examples of mutualistic associations. This photograph has an *explanatory* function.

Mutualism

Mutualism is a relation in that the species benefit themselves reciprocally, but, differently from the proto-cooperation, the co-existence is indispensable to the survival of the associated species. The lichens (figure 4) constitute a mutualistic association between algae and fungi (or between cyanobacteria and fungi). The fungi protect the algae, given them support, water, and mineral salts, creating conditions to the algae to do the photosynthesis; the food produced by the algae is shared with the fungi. Separated these fungi and algae could not survive.



Figure 4 Macroscopic aspect of lichens.

Nowadays the expression symbiosis defines an intimate association (harmonic or non harmonic) and includes mutualism, commensalism, and parasitism.

Figure 4.4- Photograph of lichen. Reproduction of the entire page of the textbook where this photograph originally appears. In the original, the text was in Portuguese and the photograph in color.

4.3.3. Developing Strategies to Conduct the Interviews

My major interest is related to the role of photographs, captions and texts in the actual process of reading. I therefore decided to make use of two different strategies that allowed me to better investigate these roles. I initially presented the orchid (Figure 4.1) and camouflage photographs (Figure 4.3) apart from their captions and main texts. After the students had talked about what they were seeing in the photograph, I presented them with the respective caption that originally accompanied

the photograph in the textbook. Finally, I presented the main text associated with each photograph. I expected to be able to follow the reasoning that takes place when students are faced with different kinds of information, different kinds of texts that complements each other, in this case, photograph, caption and text. Students were asked to read the texts aloud and comment on them. While some students read the entire texts without interruption other students commented while reading the texts.

My second strategy was to show entire assemblages of photograph, caption and text at once. I proceed in this way with the caterpillar (Figure 4.2) and lichen photographs (Figure 4.4). The intention was to present the photographs as they might appear in the textbook, allowing me to study which meaning-making resources students would identify and how they would use them in their interpretations. However, as there was no text directly associated with the caterpillar, an example of a *decorative* photograph, I presented the entire page where the photograph originally appears in the textbook.

I developed an interview guide, containing central questions that should be asked. I was careful to avoid questions that could direct the interviewees towards particular features in the photograph. Nevertheless, the nature of the interview and any word that the interviewer says has to be considered as a potential meaning-making resource to the participants. If students used some such aspect in their reasoning, I

would expect that it directly or indirectly shaped the answers given. I address this particular issue and provide some examples of it throughout this article.

4.3.4. Analyzing the Data

The twelve interviews were transcribed and subsequently translated from Portuguese to English. Once the transcripts in English of the twelve interviews were completed, I began my analysis following the principles of Interaction Analysis (Jordan & Henderson, 1995). My supervisor and I read the transcripts individually, identifying relevant issues. Then we met and discussed them together. After our first meeting, we decided to focus our analysis on one photograph at time, proceeding to the analysis of the segment of the interview related to each photograph in each one of the twelve interviews. We met again for a collective analysis after the analysis of each photograph was finished. Each interview segment was analyzed following this procedure. An overall analysis of the entire interview was conducted at the end of the segmented analysis.

4.4. Findings

“The picture helps to understand the text as much as the text helps to understand the picture.” (Faith, grade 10 student)

Through my analysis, the dialectic nature of the relationship between photographs and its associated texts became evident. The various meaning-making (semiotic) resources available to the readers when reading textbooks where photographs are used were identified and carefully assessed from the students’

responses during the interviews. Among the important aspects derived from my analysis, the differences between single and multiple photographs, the diverse functions of captions, and the importance of the main texts to the interpretation of photographs were salient.

4.4.1. Single and Multiple Photographs: Internal versus External Comparisons

During the interviews, I presented the students with the orchid and the camouflage photographs according to the same strategy: at first, the photograph was shown isolated from its accompanying caption and texts; followed by its caption, and finally the associated main text. In each case, I asked the students to tell me what they were seeing in the photograph. Students' responses to this request was to point out details identified in the photograph and qualitative characteristics of the photograph itself or of some of the objects that they identified in the photograph. The terms they used to identify each object in the photograph varied, but I grouped them according to what they referred to in the photograph.

There is a considerable variation in the students' description of what a photograph shows. For example, concerning the orchid photograph, three students suggested that the photograph represented "many trees." Four students identified the central tree and five students pointed out the orchid as the topic of the photograph. The students reacted in a very similar way when commenting about the photographs of camouflage, immediately pointing out some object presented in the photograph. In

this case, however, the twelve students mentioned the birds (three birds, three animals, eagle, falcon).

The students' immediate reactions to these photographs were in accordance with what they had been asked. The students were concerned about providing an appropriate answer to the request "tell me what you are seeing in this photograph" by means of finding focal points in the photographs. Their responses were constrained by the interviewer's way of phrasing the activity, insofar as asking "what are you seeing in this photograph?" implies a different context than if the question had been, for example, "what is this?"

Photographs have enormous amount of detail, compared, for example, to diagrams or graphs that make use of empty, white surfaces (Bastide, 1990). This abundance of detail lent itself to a proliferation of interpretations not only between but also within students. Thus, continuing their observation of the photographs, the same students pointed out many other aspects of the photographs. About the photograph of the orchid, the majority of the students (ten students) pointed out the presence of many trees in the picture. This was also the detail with most variation in the term used by the students to refer to it, for example, vegetation, forest, garden, park, and so on. The next most cited object was the central tree in the photograph (nine students). Six students pointed out a plant, which I infer as being the orchid in the picture, and six students actually pointed out the existence of an orchid in the photograph. Five students identified the lichens in the trunk of the central tree; and

four students identified the yellow flowers on the right side of the photograph.

Two students pointed out the grass on the ground in the photograph, and only one student identified the sunlight in the top of the photograph. One student referred to the presence of a parasite plant in the photograph, what later in the interview became evident as being the orchid, and another student pointed out the presence of a fern, again in reference to the orchid in the photograph.

In a similar way, students identified many different entities in the photographs that represented camouflage: five students identified the environment around the animals in the photographs, and four students noticed the difference in the plumage of the birds in the three photographs (different feathers, different colors). Three students referred to a difference in seasons in the photographs (also referred to as difference in temperature or climates). Ten students out of the twelve interviewed attempted to describe each photograph separately, emphasizing differences between the birds, the environments and/or the seasons represented in the three photographs.

To actually see “camouflage,” the viewer has to perceive what is invariant across the three images in the face of evident variations. That is, the viewer has to see the three evidently different birds as the same entity, which adapts to seasonal changes in more or less the same environment. That is, although neither birds nor environments are perceptually the same, they need to be seen as representing the same. Seeing sameness in the face of difference cannot be taken for granted—in fact, the viewer has to be instructed to be able to view photographs in this way

(Livingston, 1995). Seen in this light, it is not surprising that the differences in environment and in the bird itself were the most salient details across the three photographs. Other details, for example the fact that a white bird was in a white environment, or a black-and-white bird was in a similar environment—specifically what constitutes the phenomenon of camouflage—did not catch the attention of the majority of the readers. The students perceived the changes in the photographs, the differences in the environment and the differences in the plumage of the bird; six students even said the topic of these photographs was the environment. Two students named the birds to be the topic of the photographs, whereas two students said it was the birds in relation to their environments. Only two students said the topic of the photographs was camouflage, and they were the only ones to point out the fact that the birds in the first and in the third photographs were similar to the environment, and that this would make it more difficult for predators to find the birds.

To understand why students may not have seen the series as an instance of camouflage, I analyzed the entities that they viewed as salient. Thus, in considering the first, leftmost photograph of the series, the students identified a white bird and referred to the environment as snow, ice, or simply as “cold.” The third, rightmost photograph of the series was said to represent a brown bird in a field or mountain (students also mentioned “grass,” “rocks,” and “hot climate”). The second, middle photograph generated a greater variety of answers. About the bird in this photograph, one student said it was black-and-white, another said it was more-or less white, and

yet another student said the bird was tiger-like. But the majority of the students did not refer to the bird, describing only the environment in this photograph. The environment was identified as a river or running water, and also as intermediate temperature; only one student said it was melted ice. One student said about this second photograph that it was changing with the heat, although it is not clear if the student was referring to the bird or to the environment, or even to both. Three students also said that they could not understand this second photograph in the series. That is, the very assumption underlying the pedagogic function of the photographic series, perceiving sameness in the face of difference was not given.

The difficulty the students had identifying the environment in this photograph as the transition between winter and summer may be due to the fact that in Brazil the winter is very mild, and none of the students interviewed had ever seen snow or frozen lakes and rivers other than on television or books and magazines. Therefore, students' life experiences influenced their interpretation of the photographs; thus Brazilian students did not easily identify aspects that a U.S. or Canadian student might easily identify in this photograph.

Given the variation in salient photographic detail within students, it probably does not come as a surprise that students failed to identify the concepts that were to be taught by means of the representations: students did not see the photographs as illustrations of the concepts inquilinism and camouflage. Without the caption or text, identifying specific concepts appears to be near to impossible. Nevertheless, six

students talked about the orchid, identifying it as “orchid” (four students) or as “the plant,” and referring to it as attached to the central tree, or growing on it, or yet hanging on its trunk. They also talked about the orchid as a plant that depends on other plants to survive (one student), or as being a parasite plant (one student). In this case, however, one should take into account the fact that in the bottom-right corner of this photograph, the word “orchid” could be read. This detail could be regarded as a meaning-making resource for identifying something relevant in the photograph, but it is certainly not enough to justify students’ comments about the association of orchid and host plant.

Characteristically, a series of photographs invites the readers to pay attention to the differences between each photograph, by means of comparison. In a series of photographs the isolated figure takes on a meaning only in an external system of comparison; the internal comparison of the object with its background is scarcely informative (Bastide, 1990). Through the work of comparing, the reader distinguishes details that differ across and those that are invariant in the photographs. By focusing their attention on the noticeable changes in the three photographs, the students actually missed the invariant aspects (or, at least, in two of these photographs) required to see the concept of camouflage.

In the photograph of the orchid, the students could only draw on internal comparisons. Therefore, the majority of the students opted for the criteria “focus” as relevant means to identify the important objects in the photograph, in this case

distinguishing “background” and “foreground” in the photograph. Whether the relevant details were in the background or not is completely up to the reader in the present situation. Although common sense suggests that a photograph as a depiction of something will primarily focus in the very object that it is trying to depict, the same photograph can be used for very different purposes, and the attention can be drawn to any detail, other than the one that seems to be the focal point in the photograph.

4.4.2. Captions

After pointing out several aspects of the photographs, the students claimed there was nothing else to be pointed out. At this time, I presented the students with the captions of the photographs. These constitute additional semiotic (meaning-making) resources that could constrain how the photographs are interpreted—given that the relation is actually perceived, which is an empirical matter even though it is made highly probable because of the fact that they were introduced by the interviewer.

After reading the caption of the photograph of the orchid, which stated only “Fig. 83.1 Epiphyte plant,” all the twelve students worked to find the epiphyte plant in the photograph. The majority of the students (nine) correctly, even if tentatively, identified the epiphyte plant in the photograph. Three of these students actually referred to the orchid as being the epiphyte plant, and six students, although they could not say that the plant was an orchid, pointed it out as being the epiphyte plant

in the photograph. Besides two students who already knew orchids from nature, the other seven students proposed the orchid as the epiphyte plant in the photograph because it was the most focused or centralized object in the photograph. For example, Ruth (ninth grade) pointed to the orchid in the photograph and said that was probably the epiphyte plant “because it is the most visible one, the one that is more like, like in the middle.” Reading the caption, the students focused their attention on a specific detail in the photograph, even though they were still not able to unmistakably identify the epiphyte plant in the photograph.

This photograph had been classified as illustrative in chapter 2, because its caption provides only a name for the object or phenomenon the photograph is about. There was nothing else in the caption that could help the readers identify this object or phenomenon. Therefore, it was not surprising that some students were confused about which plant was the epiphyte plant in the photograph. For two students, the epiphyte plant could be either the central tree or the orchid, and another student believed that the epiphyte plant was the fungus on the branches of the central tree in the photograph. This confusion is justified, insofar as the photograph could be used as an illustration of lichens or of another plants as much as an illustration of an epiphyte plant. The presence of the caption referring to “epiphyte plants” appears to exclude the possibility of the topic of this photograph being other plants than the orchid. However, considering that the students did not know what an epiphyte plant was,

anything recognized as a plant in the photograph could be the object that this caption was referring to, including lichens.

Although the caption does not provide the readers with any resource that could help them to efficiently identify the epiphyte plant it refers to, most students pointed to the true referent of “epiphyte plant” in the photograph. The caption allowed these students to separate and evaluate the gratuitous detail, which carries no relevant information (Myers, 1990), attribute it to the background, and consequently disregard it as irrelevant. In doing so, the relevant details actually become salient foreground, the real topic of the photograph.

Andy (grade nine) gives a good example of this procedure. He identified the photograph as representing a plantation. When asked about what was the topic of the photograph, he said it referred to “the part of the trunk of the tree” while pointing to the central tree. He justified this by saying, “it’s more concentrated here,” while outlining the trunk of the central tree in the photograph. He further explained that if the photograph was about the plantation, it should have focused also on all the other plants in the background. After reading the caption, Andy identified the leaves (orchid) on the side of the trunk of the central tree as the epiphyte plant, and then he proceeded to analyze the photograph: “if you analyze, really, there is only the trunk of the tree like there isn’t its top, but then there is here this more focused.” In this example, the student actually engaged in the process of analyzing the photograph to separate background and foreground, and to distinguish between gratuitous details and

the intended topic of the photograph. Andy focused on the objects in the center of the image, which were in sharper focus, that is, the central tree and the leaves attached to it. He further refined his analysis by pointing out the absence of the tree top, which led him to perceive the tree as a secondary rather than the primary object of the photograph; rather, the leaves attached to its trunk were the more likely topic. The fact that the student regarded the orchid as something alien to the tree and not as “the leaves *of* the tree” was relevant in his work of interpretation of this photograph. He could separate “tree” and “leaves” and then decided which one was more likely to be the topic of the photograph, making use of other visual information displayed in the photograph to do just that.

In the case of the multiple photographs of camouflage, however, students’ reactions after reading the caption were very different than when they read the caption accompanying the photograph of the orchid. Before reading the caption, only two students described the three photographs as depicting a sequence; five students perceived the birds to be of different species. After reading the caption, all the twelve students saw the three photographs as constituting a sequence of seasons or climates and that the bird represented in each photograph was the same animal. The most salient difference in the students’ answers after they have read the caption, however, was related to the phenomenon of camouflage itself. Once the students had read the caption, they pointed out the fact that the white bird in the first photograph of the series was camouflaged, and it was almost impossible to see the bird in the

photograph except for its beak and eyes. The same occurred with the last photograph in the series, where the students identified the phenomenon of camouflage. The fact that all the twelve students agreed upon these aspects of the series of photographs reinforces the idea that the complementary caption is preferable to the illustrative or explanatory captions, insofar as complimentary captions helped identifying those elements that are required for understanding the representation in the way it was intended. The caption not merely described what was in the photographs but in fact taught the viewers what to identify as relevant detail. The caption enabled students to notice the relevant aspect of these photographs.

However, this particular series of photographs and its associated caption reveal also a problematic dimension, as the photographs and caption introduce two different concepts at the same time, camouflage and adaptation. After reading the caption, three students described the series as presenting camouflage, six students referred to adaptation, and three students suggested the series represented both. An important part of the confusion was centered on the second photograph; some students even said that the bird in this second photograph was not well camouflaged. Few students pointed out that this second photograph was in fact representing the change the animal goes through from how it is in the first photograph to how it presents itself in the third photograph, which lends itself to infer that these students identified the phenomenon of adaptation.

The students could not make sense of the second photograph in the context of the concept of camouflage presented by the caption. The students demonstrated they understood the phenomenon of camouflage (two students even mentioned military strategies during a war and how the soldiers camouflaged themselves as examples of camouflage), and they identified the phenomenon of camouflage in the first and in the third photographs of the series, where the bird was very well camouflaged in its environment. They emphasized that the phenomenon of camouflage was very well illustrated in these two photographs; but they also pointed out that the photograph in the middle was not at all necessary. As a matter of fact, this particular photograph was only pertinent in the context of the visualization of the phenomenon of adaptation. That is, the second photograph actually interferes with the development of the camouflage concept, because it is a counter example. The caption further contributes to the confusion of camouflage and adaptation insofar as, in describing the photographs, it emphasizes the phenomenon of adaptation, but ending this description with a descriptor “good example of camouflage.” The caption refers at the same time to both phenomena of camouflage and adaptation, without however helping the reader to identify the two different phenomena represented in these photographs.

4.4.3. Main Texts

After students had completed their interpretations of photographs and captions, they were presented with the main text associated with each photograph.

Each text constitutes another set of semiotic resources that students can draw on to make sense of the photographs—whether they in fact do is an empirical question. In the present situation, the introduction of the main texts led to further changes in the students' interpretation. For example, after having completed the main text with which the orchid photograph was associated, all twelve students recognized the topic of the figure as being related to the orchid, and they then identified the leaves on the central tree as belonging to the orchid. Frequently, however, this identification still was based on an assumption and not a certainty about what was really the epiphyte plant or the orchid in the photograph, as students still exhibited doubts about it.

In the case of the camouflage series, the main text is about camouflage, explains the concept, and provides several examples of camouflage. However, the main text refers little to adaptation, no more than stating that camouflage is a kind of adaptation. After reading the main text, ten students believed the topic of the photographs to be camouflage and only two students said the topic of the photographs was adaptation to the environment. Nevertheless, the students expressed confusion about the phenomenon represented in the photographs. Although the main text explains the concept of camouflage, the students perceived more than camouflage: they also saw adaptation to the environment in different seasons. The phenomenon of adaptation was not present in the main text, but it was described in the caption. What happened then was that the students tried to make sense of the series of photographs, and its

sequential nature, in the context of camouflage, incorporating the process of changing that actually illustrates the phenomenon of adaptation, as part of the phenomenon of camouflage.

Most importantly, the main text and caption cannot assure that students will actually interpret the photograph in the intended way. Misreading of the text can still occur, as for example, in the case of a student who identified the orchid as being the epiphyte plant, and a bromeliad as being the host tree. In this case, the misreading of the text was easily identified, as the student read “orchids *and* bromeliads,” instead of “orchids *or* bromeliads” in the sentence, “It is the case of the interaction between orchids or bromeliads and the trees in which trunk they are installed.” This misreading of the text (*and* instead of *or*) accounts for the misinterpretation of the photograph and even of the entire concept presented in the text, insofar as the student perceived bromeliads as the host trees instead as another plant in the same category as orchids (e.g., “the orchid is in a bromeliad, without causing any damage to it”).

In this particular case, the textbook author used the photograph to illustrate the *interaction* between orchids or bromeliads and the host trees. Yet this interaction is not visually available in the photograph. Rather, it shows what an orchid looks like on the trunk of a host tree in a natural setting. The way in which this information was provided in the main text accounts for the possibility of different interpretations of the photograph. The text actually does not make explicit if the photograph presents an orchid or a bromeliad, only that these are examples of epiphyte plants.

Furthermore, when reading the caption the student readers did not have additional semiotic resources that could help them to decide whether the photograph was showing an orchid or a bromeliad in the trunk of the tree. Thus, although the student in this case misread the text, complete confusion would have been avoided or at least minimized if the text (or the caption for that matter) had explicitly instructed the readers that what they could see in the photograph was an orchid, and that orchids, as well as bromeliads, were epiphyte plants.

4.4.4. The Work of Reading the Text and Photograph Simultaneously

Presenting the students with the entire assemblage of photograph and texts allowed me to investigate the actual work of reading that the students engaged in when reading textbooks with illustrations such as photographs. In these cases, I introduced the entire assemblage of photograph and texts together: I reproduced the entire page of the textbook where the photographs appeared and handed it to the students. The students were then asked to talk me through their reading of the page.

4.4.4.1. Common Functions of Photographs

One of the aspects that became salient in my analysis was the primary function that every photograph has in calling readers' attention. In the case of the photograph of the caterpillar, this function is not only the primary function as it is the only function of this photograph in the particular page where it originally appears in

the textbook, insofar as this photograph had been previously classified as decorative, meaning that it does not present a caption or reference in the text associated with it.

During the interview, as I handed the reproduction of the page of the textbook to the students, the first thing ten students said was that they were looking at the photograph; only two students stated that they were reading the title of the text or “looking at the text”. In the case of the photograph of the lichens (an explanatory photograph that presents a caption with a brief explanation about what can be seen in the photograph), although only five students actually stated that they were looking at the photograph, it is easily noticeable from the videotapes that all the twelve students looked at the photograph before either talking about it or starting reading the text. The students’ attention was immediately caught by the illustrations. As Cameron (grade eight) stated, “you look at an illustration, you will want to see what it is, if you are interested in the picture, you will want to read what is beside it, or below it, or above it”; if the texts then do help the students in identifying what the figure is about, the pedagogical role of photographs is increased.

4.4.4.2. Contextualization in the Work of Interpretation

Another aspect that emerged from my analysis is related to the importance of the context of the photographs for students’ work of interpretation. When presented with the textbooks’ reproductions, all twelve students were asked to either describe what they were seeing in the photograph or read the text aloud. About the photograph

of the caterpillar, five students said the photograph presented a caterpillar; three students said it was a centipede, and two students referred to the animal just as “a bug.” One student said it was a worm, and another one identified it as an insect. Although the term used varied, all the students were able to identify the animal in the photograph.

Other characteristics were also identified in this photograph: two students made references to where or when this photograph was taken, “in a closed space” or “at night,” because the background was dark. These two students also inferred other aspects of the photograph; one of them said, “this is a small bug,” and the other stated that, “it must stop to be able to eat.” It is noticeable in these cases the influence of previous knowledge and conventions of perspective in the interpretation of photographs.

In the case of the photograph of the lichens, however, students’ reactions were different: only three students commented about what they were seeing in the photograph, while other two students who did not start reading immediately only said they were looking at the picture, without any further comment about it. The other seven students, although they certainly looked at the photograph, did not make any comments whatsoever about the photograph, and decided to start reading the text instead. This suggests that the students, with the exception of those three who actually tried to describe the photograph (and were familiar with lichens), did not identify anything in the photograph, and therefore they turned their attention to the

text, searching for information that could help them to figure out what the photograph was all about. Only four students identified the background of this photograph either as a tree or a rock. Insofar as this information could not be found in the texts, the students relied on previous knowledge to identify the background of the photograph. The identification of the background is important because it allows the reader to distinguish the relevant details in the photographs. When this identification is not possible, the interpretation of the photograph is jeopardized.

Comparing this situation with the one presented by the caterpillar photograph it is noticeable that in the latter case, students were immediately drawn to the photograph. Although they all read the text, they only did so after commenting on the photograph. This makes it plausible to assume that students did not know what the photograph was about. The visual information provided was insufficient to help the students interpret the photograph, and the texts associated with this photograph not only were important for directing the readers towards a specific interpretation, but also were essential to the reader to construct an understanding of this photograph.

The analysis of students' responses also revealed evidence of the influence of common sense and life experiences on the interpretation of photographs. For instance, when commenting on the caterpillar photograph, eleven students said the animal in the photograph was eating, feeding, or gnawing a plant or a leaf. Because the photograph is static, "eating" has to be inferred. While "eating" itself cannot be seen, possible evidence for it can be detected. Such evidence is built upon the difference between

what one can see and what one may think, has heard, or believes (Amann & Knorr-Cetina, 1990). Here, the shape of the leaves is different than students knew it from experience; this difference can be hypothesized to be bite marks, and the caterpillar can be assumed to be responsible for these bites. A lot of previous knowledge and common sense, as well as conventions of perspective, go into the work of interpreting this photograph in this manner. It is assumed, for instance, that caterpillars eat plants, or at least, leaves; therefore, these animals should have a mouth, and this mouth should be able to imprint a particular kind of mark in the leaves. All these details cannot be seen in the photograph and yet they are crucial aspects of the work of interpretation.

4.4.4.3. Indexical Reference and Photographs

High school biology textbooks inconsistently use indexical references, such as “Fig. 30.2” that link a particular segment of text (sentence, paragraph) and photograph; some photographs are not linked to the text at all, as shown in chapter 2. My study was explicitly designed to generate hypotheses about the role and importance of the indexical reference to the work of interpreting photographs and their co-texts. The orchid and the lichens photographs were accompanied by texts that presented indexical references to the figures, whereas the caterpillar and camouflage photographs were not referred to in the text.

In the case of the camouflage photographs, the absence of an indexical reference did not appear to be problematic at all, perhaps due to the distribution of

text and figure in the page of the textbook. The text was placed in two columns and the figure was placed immediately below these columns. This arrangement allowed the student readers to move from text to photograph in a continuous manner. In this case proximity accomplished what otherwise could only be accomplished with the presence of an indexical reference. The effect was different for the decorative photograph, here exemplified by the caterpillar photograph. In this situation, the lack of indexical reference aggravates the difficulty of associating photograph and text, particularly given the further absence of a caption. For instance, the text near the caterpillar photograph introduced the chapter topic; it was structured according to a typical pattern of the textbook in which it appeared: the first page of each new chapter presents a decorative photograph and an introductory text, as well as some highlights of the topics that would be presented in the chapter. While reading this text, four students identified the text as a summary or an introduction of what would be presented in the chapter that followed; eight students failed to identify this characteristic of the text and therefore were faced with increased difficulty in determining the function of the photograph in that particular text. When asked if there was any relation between the text and the photograph, two students said the photograph did not have anything to do with the text. Six students said they could not understand the photograph (students also said that the text did not help to understand the photograph, or that they could not know what the text was about, or yet that the

photograph diverted from the text). Seven students said the photograph could be substituted by another photograph without altering its relation with the text.

Despite the difficulties, and the lack of caption and index, all students suggested that photograph and text were associated in some way, probably relative to living beings and the environment (students also mentioned ecosystem and biosphere). This relation, however, is a very general one and could refer to every single figure and text in this biology textbook. When asked about a more specific relation, there were as many different answers as there were students interviewed. That is, the students said the photograph was illustrating or exemplifying something referred to in the text, and each student believed this was a different thing: the natural cycles; the distinction between autotrophs and heterotrophs; the food chains; the particular environment (or ecosystem) where the caterpillar lives; the relation between the plant and the caterpillar; the importance of eating to surviving; the relation of human beings and the animals (and the fact that we should respect the animals); and metamorphosis. These were cited as possible topics of both photograph and text, and these topics supposedly explained the relation between photograph and text.

What happened in this situation can be understood in terms of authentication (Bjelic, 1992). In this process, a photograph is viewed as evidence supporting the text, in fact, because of its lifelike quality, authenticating what the text describes in words. In relating the text and photograph, the students attempted to find a specific function to the photograph, that of illustrating something referred to in the text. They assumed

the photograph was helpful in some way to understand the text, and they struggled to justify this assumption by directly connecting text and photograph, even if this connection was not explicit. The lack of resources that definitely and directly linked photograph and text therefore gave rise to a level of indeterminacy that accounts for the great variety of topics students proposed as the content of the photograph.

When a definite and direct link is provided, the level of indeterminacy should be decreased. Thus, while reading the text associated with the lichen, six students actually referred to the figure at the exact point in the text where the indexical reference was placed. Not all of them read the indexical reference aloud at this point, but they either looked at the photograph, or pointed to it, or yet said something about the figure. The students were aware that the photograph represented lichens; both caption and main text read that the photograph was about lichens, and the indexical reference appropriately placed in the text contributed to help the students to identify the “right detail,” the topic of this photograph.

Some students even stated that they already knew what lichens look like, and that they were able to identify it in the photograph before reading the caption and the main text (although only two students actually named what they were seeing in the photograph before reading the text). When asked to point out the lichens in the photograph eight students were able to do it properly, that is, they identified the

lichens against the remaining background. However, they were not sure about what the background was constituted of.

In the case of the photograph of the orchid, the presence of the indexical reference to the figure in the main text played an important role in guiding the student readers towards the interpretation of the photograph, which emerged from the association of this photograph with its caption and text. The indexical reference helped students in selecting the specific topic of the photograph in relation to the main text. In this case, for instance, the presence of the indexical reference just after the phrase, “It is the case of the interaction between orchids or bromeliads and the trees in which trunk they are installed,” leads the readers to regard the photograph as providing an example of the interaction referred to in this phrase. The readers, then, were expected to look for a plant like an orchid or bromeliad and the trunk where they should be installed.

Although not every student read the indexical reference in the main text aloud, the majority of the students (9 students) recognized the presence of an indexical reference that linked figure and text. Three students either did not mention the indexical reference or they stated that there was no indexical reference to the photograph in the main text (one student even read the indexical reference aloud when reading the main text, but he failed to recollect its existence when asked about it by the interviewer).

Although the index to the photograph of the orchid was important—especially because this photograph was an illustrative photograph, which does not present much useful information in the caption—the fact that the indexical reference was placed at the end of an entire phrase in the text accounts for an unexpected difficulty in associating photograph and text. For instance, Fran (grade nine) engaged in an effort of identifying *both* orchid *and* bromeliad in the photograph. She could not decide whether the leaves on the side of the trunk of the central tree in the photograph were an orchid or a bromeliad. She was also confused when she attempted to identify a second, epiphyte plant in the photograph thus pointing to many different trees and flowers in the photograph.

The way in which the indexical reference was used, accounts for the possibility of different interpretations of the photograph, as for example, in the case mentioned above. The reader is taken to connect figure and text through the indexical reference placed at the end of the phrase where the text refers to orchids *and* bromeliads. Insofar as in this case the caption does not help to disambiguate matters, the student could not decide if the epiphyte plant in the photograph was an orchid or a bromeliad.

4.4.5. Beyond Text, Caption, and Indexical Reference

Visual information such as color, arrows, letters, geometric shapes, and so on could be used in addition to caption and text to highlight something directly on the photograph. However, high school biology textbook authors rarely use such semiotic

resources with photographs, as I showed in Chapter 2. One example of the use of an additional semiotic resource layered on top of the photograph existed in the orchid photograph. In this situation, the information necessary for the reader to construct the topic of the photograph (orchid or bromeliad) was available in the photograph itself, existing in the word “orchid” on the bottom right. Taken by itself the information although it could still focus the readers’ interest towards something specific in the photograph, does not however help them to actually identify this specific object or phenomena in the photograph. But in the context of the entire assemblage of photograph, caption, and main text including the indexical reference, this information becomes essential for the reader to make sense of the photograph in relation to the text. Just by looking at the photograph, the students could identify the most central objects as the probable topic of the photograph; by reading the caption, they focused their attention at a plant in the photograph, and later, by reading the text, they associated the figure with the text, going as far as realizing that the photograph was showing an epiphyte plant and its host tree. However, they still were not certain about which of the examples of epiphyte plants given by the text—orchid and bromeliad—was represented in the photograph. The word “orchid” written in the photograph was the ultimate information needed to properly interpret this photograph in relation to the text. Therefore, photographs, captions, texts, indices, and a variety of other resources can and should be used to make sense of photographs when reading a textbook. The work of interpretation of photograph and text is

essentially dialectic. As the student quoted at the beginning of this section noted, the text helps to understand the photograph as much as the photograph helps to understand the text, and both text and photograph need each other in order to be properly interpreted.

4.4.6. Influence of the Interview Context on Students' Responses

Seldom addressed in the literature but nevertheless an important meaning-making resource to interview participants is the interview context itself as well as every word, sentence, and even pause produced by the interviewer (Schoultz, Säljö, & Wyndhamn, 2001; Ueno & Arimoto, 1993). In the present study, such influences were also observed. For example, while looking at the photograph of the orchid, Adam, an grade eleven student, was asked to articulate the topic of the photograph. He immediately answered that it would be the orchid, and he pointed out the orchid in the photograph. He also pointed out the word "orchid" written in the bottom right of the photograph. After reading the caption, however, Adam suddenly changed his mind. He said the plant he earlier had identified as an orchid no longer looked like an orchid, and he added that there are many kinds of orchids and the ones he knew were different from the plant in the photograph. He said he was confused and that the caption only makes everything worse. Only after reading the main text Adam returned to talking about it as an orchid and an epiphyte plant. He realized then that both denominations could be used to address the plant in the photograph.

During debriefing, Adam admitted that he knew the plant was an orchid from the beginning, he had recognized it in the photograph because he was very familiar with orchids: his mother grows orchids at home and his grandmother's garden includes many orchids growing on trees. However, when he read the caption, although he did not know what an epiphyte plant was, he believed the word "orchid" in the bottom right of the photograph was deceptive and did not have anything to do with the photograph itself. He considered the plant identified as an orchid as being the epiphyte plant referred to in the caption. He explained that because he knew the interview was part of a research, he expected some kind of trick that would mislead him.

In this case the influence of the context in the answers provided by the student is clear. Although the student answered the interviewer's question, he was also conscious of the fact that the interview was part of a research project, and his conception of the nature of research influenced his responses to the extent that he disregarded his own previous, extensive knowledge about orchids.

4.5. Discussion

Visual representations pervade our lives. From television, Internet, movies and magazines, to the curriculum materials employed at schools, visual images are widely and constantly used. Photographs, for instance, are the most frequent inscriptions present in high school Biology textbooks. Knowing that teaching and learning strategies rely heavily on textbooks, we should more carefully investigate the

pedagogical potential of photographs, and how students and teachers make use of these visual resources to achieve and help others to achieve understanding. This study is part of a series of studies that aim to answer some of the questions related to the use of photographs in school science.

How do students interpret photographs? How do they make use of the semiotic resources present in the textbooks? How do they connect photograph and text? In this study I have tried to answer these questions through careful analysis of data collected from interviews with twelve students from different grade levels.

During the interviews, I presented the students with reproductions of photographs and texts extracted from high school biology textbooks widely adopted in Brazil. I used two different strategies to show the photographs and texts to the students: (a) I presented the students with the isolated photograph at first, followed by its associated caption, and finally its associated main text; and (b) I presented them with the entire assemblage of photograph, caption and main text, as these items originally appeared in the textbook.

Some of the arguments I have made in Chapter 2 of this thesis were validated by the results encountered in this study. For instance, pairs or series of photographs present an advantage in relation to single photographs. Multiple photographs greatly reduce the possibilities of diverse interpretations of the topic treated in the photographs. External comparison provided by the use of series of photographs allows the readers to easily distinguish the important details in the photograph. It is

important to highlight, however, that a series or a pair of photographs by itself is not enough to ensure the correct interpretation of the photograph. It is the interaction of other semiotic resources presented in the textbook, together with the photographs, that made possible to the reader to interpret and understand what he or she is reading.

The caption is of major importance when using photographs for pedagogical purposes in textbooks. Captions name something that should be more carefully regarded in the photograph. Decorative photographs, without captions, proved to generate greater difficulty in associating photograph and text. Therefore, it is important that every photograph have its own caption.

A caption should always refer to whatever the photograph is supposed to be a depiction of. Illustrative photographs, as in the case of the orchid, and explanatory photographs, for example the lichens photograph, present captions that explicitly refer to the topic of the photograph. However, to function properly, captions are expected to do more than simply identifying the relevant object or phenomenon in the photograph; they should provide some explanation about this object or phenomenon and give the readers enough information so that they can in fact relate photograph and text. Captions should guide the readers through the photograph, helping them to distinguish relevant details.

When the caption fails to help the readers identify the “right detail” in the photograph, readers have to draw on resources other than the caption to identify the topic of the photograph.

The main text is certainly an important resource in helping the readers to interpret the photographs. Complete explanations about the object or phenomenon depicted in the photograph, as well as appropriate associations between the concept been presented and what can be seen in the photograph, are necessary to maximize the chances that readers will, in fact, connect and interpret text and photograph in the way expected by the textbook author.

From my analysis, it became clear that one of the major functions of photographs is to capture readers’ attention. Invariably, the students interviewed noticed and commented on the photographs before referring to the texts. Although I was careful as to take into account the influence of the interview setting as well as the influence of the interviewer herself on student’s responses, I do believe the students demonstrated interest in the photographs, even if they did not pursue the investigation of these photographs afterwards.

It is important to be attentive to intrinsic characteristics of photographs, as for example the background and framing of the photographs. Photographs with neutral backgrounds are useful to highlight the object of interest, insofar as gratuitous details are almost non-existent. Nevertheless, the lack of these gratuitous details sometimes implies in the decontextualization of the object depicted in the photograph. In the

lichens photograph, for example, I could notice how the students could not comment about the photograph before reading the text, as they could not easily identify the object in this photograph. The photograph was taken aiming to focus only on the lichens, and although these were fairly represented in the picture, they became out of context, what generated difficulties for the students to understand this photograph. Furthermore, the information in the texts accompanying this photograph was not enough to help the reader to distinguish what he or she was seeing in the background.

On the other hand, photographs as the one of the orchid also present many problems related to the identification of the important or right detail to be observed in the photograph. The abundance of details in this photograph certainly gives it realism; unfortunately, it also accounts for much confusion. The students were not able to unmistakably identify the epiphyte plant among so many other plants depicted in the photograph. Some students were not able to decide which plant was the epiphyte plant even after reading the caption and the main text. The students who did identify the epiphyte plant either made use of previous knowledge to do this, or did it after much struggle and reasoning, making use of other semiotic resources available to them, for example, guessing that the epiphyte plant was the one more focused or centralized in the photograph. I again suggest that more specific directions, such as arrows and colored areas, should be used to help the readers to identify the right detail to be observed in the photograph.

My analysis highlighted the importance of the indexical reference to the figure, especially with reference to where the indexical reference is located in the main text. These references should be placed preferably at the first time the phenomenon or object depicted in the photograph is mentioned. The indexical reference to the lichens photograph is a good example. When reading the text, the students immediately connect “lichens” with the photograph, because the index for this photograph is placed just after the word “lichens” on the text. In the case of the photograph of the orchid, however, the indexical reference placed after an entire phrase that identifies a phenomenon and not an object, confuses the reader, as I was able to see in the interview with one of the students. The indexical reference is what allows the reader to explicitly connect photograph and text; therefore, it is an important resource to help readers to interpret photographs and texts in the context of learning a scientific concept. In some situations, however, difficulties that could arise from the absence of indexical references seem to be overcome by the way in which the text and the photograph are structured in the page of the textbook (e.g, photographs about camouflage).

Many of the concepts presented in science textbooks are abstract and ask for an illustration to help readers to understand what is being introduced to them by the text. Photographs seem to be the preferred visual illustration on biology textbooks. However, for the photographs to achieve their full potential as pedagogical resources in teaching and learning science, many aspects of their use in textbooks should be more

carefully regarded. When students are reading textbooks, the way in which they interpret photographs greatly influences their understanding of the concept presented by the textbook. Therefore, careful selection of photographs, as well as appropriate captions and indexical references to these photographs constitute ways to ensure that a better understanding is more likely to happen. The interaction of various semiotic resources in the textbooks help readers in their work of interpretation and allows them to appropriately connect photographs and texts.

Chapter 5

Conclusions and Implications

In the three articles that constitute this thesis, I investigated the use and interpretation of photographs as a pedagogical resource to help introduce or teach scientific concepts both by means of textbooks and lectures. I examined the semiotic resources made available to the readers of textbooks that could help them to interpret photographs, associating these inscriptions with the concept presented in the text. Similarly, I identified the semiotic resources that exist in a lecture situation where photographs are used to explain a concept. Finally, I investigated how students interpreted photographs associated with scientific texts in real time, aiming to have a better understanding of the actual work of interpretation associated with the act of reading a textbook full of photographs. That is, this final study revealed a range of resources that students actually drew on in their sense-making work. In the first section of this chapter, I provide brief summaries of the three studies that constitute this thesis, emphasizing the major findings derived from each. In the second section I articulate the threads that integrate the three studies into a coherent whole. Finally, I describe implications that these studies have for writing textbooks and teaching with photographs.

5.1. Summary of the Three Studies

5.1.1. Prevalence, Function and Structure of Photographs in High School Biology Textbooks

In this study, I investigated the semiotic (meaning-making) resources available to the readers of high school biology textbooks for interpreting photographs and appropriately associating them with corresponding forms of text (main body, caption). My research question was, “What can students learn from textbooks when they study

photographs?” In my attempt to answer this and its subordinate questions, I analyzed the ecology-related chapters of four widely used Brazilian high school biology textbooks.

My analysis revealed that the photographs in the textbooks have different functions, ranging from a mere *decorative* function to the more complex and sophisticated *complementary* function. All photographs were counted and classified according to the four categories I developed, representing the function of photographs in the text, *decorative*, *illustrative*, *explanatory*, and *complementary* nature that they play with respect to the main text.

Decorative photographs, that is, photographs without caption and indexical reference, posed problems related to their interpretation and association with texts insofar as few semiotic resources were available that could guide the readers towards what could and should be seen in them. The lack of a caption allowed for almost infinite possibilities of different interpretations of decorative photographs; the absence of an indexical reference to these photographs in the main text made the effort of associating photograph and text a primarily subjective endeavor. Decorative photographs provide only for aesthetics aspects of the textbook, and therefore function solely as a means for calling readers' attention, which is the primary function of any photograph.

A photograph was said to be *illustrative* when it includes a caption and may or may not be linked to the main text by means of an indexical reference such as “Fig. 10.1” in the main text. These photographs are illustrations of objects or phenomena described in the main text but the captions only name the entity that readers should attend to. However, the information provided in the caption is not always enough to ensure that readers will actually be able to identify the relevant object or phenomenon in illustrative

photographs. That is, there is a lack of semiotic resources for identifying the relevant entities. This type of photographs was the most frequent in the four textbooks analyzed; despite their function as illustrations of entities and concepts, these photographs do not achieve their full potential as pedagogical resources in school scientific contexts.

Explanatory photographs go one step further than their *illustrative* counterparts in that they guide the readers through an interpretation. That is, these photographs have captions that not only name the relevant object or phenomenon to be noticed, but also provide a brief explanation about or classification of the object or phenomenon. The salient difference between *explanatory* photographs and *illustrative* photographs lies in the additional information provided in the caption of the *explanatory* photographs, which the readers can use in their interpretative work.

The captions that accompanied *complementary* photographs are the most complete captions, presenting new information not contained in the main text about the relevant object or phenomenon depicted in the photographs. This information is important to guide the readers through the interpretation of the photograph and to connect photograph and text. Both *complementary* and *explanatory* photographs, as already noted for *illustrative* photographs, may or may not be accompanied by an indexical reference that links them to a passage in the main text. In each case, their function in relation to the main text is not altered.

My analysis of the photographs in high school biology textbooks also revealed peculiarities in the way in which photographs are arranged and structured in the text, which may have a direct impact in readers' work of interpretation. For instance, indexical references sometimes are and at other times are not consistent within the textbooks

analyzed. Whereas in one textbook the indices to the figures are always placed at the end of the paragraph, another textbook does not use indexical references at all. The remaining two textbooks present variations, at times inserting indices just after first mentioning the object or phenomenon depicted in the photograph, or at the end of paragraphs, or even sometimes presenting photographs without any indexical reference.

Indexical references constitute important semiotic resources that readers may rely upon during their work of reading a textbook full of illustrations. Misplaced indices, that is, indices that occur in the main text far from the sentence or word directly associated to the photograph, may confuse the reader, as showed in Chapter 4, and make the interpretation of the photograph as well as its association with the text much more difficult. Even worse is the case of a complete absence of indexical reference, when readers have no means of immediately associating photograph and its corresponding text, insofar as they do not know when to look at the photographs while reading the text. Similarly, when looking at the photographs, the readers cannot know where to go in the text to find out more about the relevant concept without going through the entire text.

The ways in which photographs are arranged in the textbooks may also influence readers' work of interpretation. Multiple photographs representing the same object or phenomenon at different times, in different situations, or in different locations constitute at times an assemblage preferable to single photographs insofar as readers are able to engage in external comparisons between the photographs, identifying everything that changes as well as everything that is constant on the photographs. Single photographs allow only internal comparison, which makes it more difficult to identify relevant details. Single photographs inherently pose problems arising from the presence of much

gratuitous detail that constitutes the background to the object or phenomenon making figure-ground distinctions difficult for the novice. Although one can argue that all the gratuitous detail is necessary to contextualize the phenomenon by making the scene more realistic, gratuitous detail produces “background noise,” that makes identifying relevant figures more difficult. In some situations, therefore, the use of a neutral background is preferable, although it is always important to avoid a decontextualization of the relevant objects or phenomena actually depicted in the photographs.

Semiotic resources layered directly onto photographs such as, for example, arrows, color schemes, framing of the photographs, and so on, are rarely found in textbooks. But even if such additional resources existed, photographs, as all visual illustrations would still be open to diverse interpretations. What can be done then? Projecting photographs in such a way that allows some “teacher” to gesture and position him- or herself in relation to the photograph, with both speaker and photograph visually available to the audience, might be a more efficient strategy in providing semiotic resources to help to interpret photographs. My second study was designed to investigate the semiotic resources made available in lectures for understanding photographs.

5.1.2. Photographs in Lectures: Gesture and Body Orientation as Meaning-Making Resources

Photographs achieve new dimensions when they are used in lectures, which provide resources that are not possible in a textbook. My study showed that in a lecture situation, especially when both speaker and inscription are perceptually available to the audience (which is not the case, for example, in darkened lecture halls), the meaning of the photographs can be constrained, multiplied or amplified. In the second study of my

thesis, I investigated the use of photographs in three different types of lecture situation: (a) when both photograph and lecturer are perceptually available to the audience; (b) when only the photographs are perceptually available to the audience, as they were being presented in a dark auditorium; and (c) when both photographs and lecturer are perceptually available to the audience, but the lecturer is making use of transparencies, and his/her gestures are made in the direction of the transparency instead of the projected image. These three situations presented contextual differences that helped me analyze the role gestures and body orientation play as semiotic resources.

My analysis revealed that gestures are the most important semiotic resources available to the audience to interpret photographs in a lecture situation. Therefore, I developed categories according to the functions of the gestures in relation to the photographs. My classification includes eight categories of gestures differing in the *representing, emphasizing, highlighting, pointing, outlining, adding, extending, and positioning* function they had with respect to features in the photographs. All the gestures from the three different settings analyzed could be included in one of these eight categories, although I chose gestures from only one of these settings to exemplify each category. I counted the gestures and exemplified each category with gestures extracted from the lesson an environmentalist gave in a seventh grade ecology class, dealing with the concept of watershed.

Representing gestures were the most frequent in the lesson about watershed. In these cases, the lecturer was always fully or sideways turned towards the audience, and her gestures represented something not visually available in the photograph. These gestures were iconic and general, as they represented, for example, the slope of a road.

Emphasizing gestures are directed towards the photographs, as the objects or phenomena to which they refer are always available in the photograph. They occur in the form of iconic gestures, but at the same time, have deictic function as well, as for example, when the lecturer emphasized a river in the photograph, generally following its course. *Emphasizing* gestures were always generic.

When the lecturer highlighted something in the photographs, she was always turned towards the photograph. *Highlighting* gestures are deictic, general, and usually circular; they identify an object in the photograph, without however clearly delimiting its boundaries. *Pointing* gestures are very specific deictic gestures that use the photograph as background. *Outlining* gestures are specific gestures that are both deictic and iconic in nature. The lecturer was always turned towards the photograph when she outlined an object, as for example, when she outlines a lake, carefully following its boundaries.

The lecturer's gestures can also add something to the photograph that cannot be seen in it, as for example, when she outlines the event of an oil spill happening in the heights of a mountain and flowing down into a lake. These gestures add something to the photograph beyond what can actually be seen in it. *Extending* gestures are deictic and specific gestures with the lecturer always turned towards the photograph, pointed to something that would be in the photograph had it been taken from a greater distance. Finally, *positioning* gestures are iconic and general, and the lecturer is turned towards the photograph integrating the lecturer's current position thereby opening up a third, spatial dimension within which to understand the photograph.

All forms of gesture and associated body positions constituted semiotic resource that are deployed in addition to speech for helping in the interpretation of photographs. In

various ways, the gestures constrain, amplify, and multiply meaning. They open new dimensions, make salient specific elements and entities, constrain the extent of a specific object or phenomenon, add new events, and contextualize the contents into the lived spatial world as well as making explicit the connection between photograph and speech.

5.1.3. Making Sense of Photographs

In the first two studies of this thesis, I investigated the semiotic resources made available by textbooks and lecturers for understanding photographs. One aspect of photographs remains, “How do students interpret and make sense of photograph when they are reading textbooks?” In order to answer this question, I videotaped 12 students interpreting photographs and associating them to texts. That is, I investigated how students actually used the various semiotic resources available in the textbooks to associate and interpret photographs.

I selected four photographs and texts from the high school biology textbooks analyzed as part of the first study of my thesis, representing different types and functions. The photograph of the caterpillar represented a *decorative* photograph; the photograph of the orchid was classified as an *illustrative* photograph, and the photograph of the lichens represented an *explanatory* photograph. The photographs of camouflage consisted of a sequence of three photographs and they were classified as *complementary* photographs. These photographs were presented to the students according to one of two different strategies. The orchid and camouflage photographs were presented to the students isolated at first, followed by the presentation of the caption, and finally the presentation of the associated text. The caterpillar and lichen photographs were presented to the

students simultaneously with the text, just as they appeared on the page of the textbook where I had excerpted them.

This study revealed that multiple photographs present an advantage in relation to single photographs; two or more photographs, presenting a dynamic of invariant and changing aspects, have the potential to reduce the possibilities of diverse interpretations. Thus, students' responses in the case of the camouflage series were much more congruent than their responses in the case of the other single photographs.

The various functions of captions and the difficulties that arise when a photograph was not accompanied by an appropriate caption were salient features of the student interviews. Students did better in their interpretations when captions not only named relevant objects or phenomena but also guided readers through their interpretations, eventually even providing new information. Students had difficulties in associating photograph and text when the caption was absent, as well as when the information provided in the caption only named an object or phenomenon, without providing any explicit guidance that could help to appropriately interpret the photograph.

The main texts proved to be important semiotic resources for interpretation of photographs when these inscriptions are used to help teach a scientific concept. When the information in the main text was insufficient, students could not satisfactorily associate photographs and texts. Students' interpretation of a photograph was jeopardized when the indexical reference to a photograph was misplaced in the text. Absence of indexical references proved to be problematic, although in some cases the page layout, with text and photograph structured such as to provide a continuous reading, could greatly reduce the effects of the absence of an indexical reference.

The absence of alternative semiotic resources inserted directly on the photograph itself was another factor that made the interpretation of the photographs more difficult. This was especially the case when the students were interpreting single photographs full of gratuitous background detail, as for example, the photograph of the orchid. On the other hand, it also became evident that decontextualized photographs are problematic. For example, although the students could say that they were looking at lichens because both caption and main text assured them the photograph was depicting lichens, they had great difficulty in understanding what lichens were, where they could be found, and so on, because of the absence of context in the photograph.

5.2. Integration of the Three Studies

Collectively, the three studies are concerned with the use of photographs in teaching science and how students interpret photographs and the embedding text. The sciences, especially biology, include many experience-distant, unfamiliar, context-independent (i.e., abstract) concepts that teachers need to teach and students need to understand. In trying to do so, teachers rely on textbooks, which in turn present an enormous amount of visual materials, photographs constituting the most frequent of them. Also, teachers even reproduce and project photographs in their classrooms. Understanding why photographs are so widely used in teaching and learning approaches in science education becomes, therefore, an urgent topic for research. I do not pretend to have addressed and exhausted the entire topic. Yet my three studies helped answer some of the important questions related to the use of photographs in teaching and learning science. If a photograph is indeed to be worth ten thousand words, we—teachers, authors,

and students—should ensure that we are in fact enabling those ten thousand words to emerge that are truly pertinent to the topic at hand.

In my first and second studies, I investigated the semiotic resources made available in textbooks and lectures, respectively, where photographs are used in the teaching of scientific concepts. In textbooks, photographs are co-deployed with a variety of semiotic resources that have the potential to help the readers interpret the photographs and connect them to the concept treated in the text. Similarly, in a lecture situation the projected photograph is accompanied by speech and gestures that constitute important semiotic resources to help the audience interpret the photograph. A parallel can be drawn between these two situations, and many aspects of the use of photographs for pedagogical purposes then become salient.

First, the nature of the texts that accompany the photographs greatly differs between the two situations. In a textbook, texts are always written, whereas in a lecture, speech and gestures have to be taken into account together as a different type of “text” co-deployed with the photographs. These two different types of text present intrinsic characteristics that constrain their simultaneous use with the photographs. For instance, a photograph in a textbook requires an associated written text that, in order to assure that the relation between photograph and text would be appropriately established by the reader, would have to be a very descriptive, complex and sophisticated text. The same photograph used in a lecture situation, where both illustration and speaker are perceptually available to the audience, would require only a much simpler text, as speech and gestures together constitute a means of communication that is at the same time, simpler and more objective.

In a lecture situation, speech and gestures “transform” the photographs; new dimensions are opened in relation to each photograph, and at the same time a clearer—because more direct—guidance is provided for the interpretative trajectory through the photographs. In a textbook, written text could also “transform” the photographs; much of the “transformation” would still be a result of the readers work of reading and associating text and image no matter how complex, detailed, and sophisticated the text might be.

Considering the eight categories of gestures I described in chapter three, at least three of them, *representing*, *extending*, and *positioning*, do not have parallels to a textbook situation. That is, what the gestures do in relation to the photographs in these three cases is something that cannot be reproduced in a textbook. These three categories of gestures “transform” the photographs from a two-dimensional depiction to the three-dimensional space, inserting them back in the real world of which a portion is depicted in the photograph. Achieving something similar in a textbook, if at all possible, could only be done with an enormous amount of text, describing the area the photograph depicts, and trying to explain exactly from where, and how, and when the photograph was taken. Furthermore, this work would again have to be done by the reader rather than the presenter of the information. Such text probably would not be worthwhile having in a textbook, especially because it does not “transform” the photograph in the way speech and gestures so easily do.

Four other categories of gestures may have textual equivalents to a textbook situation. Additional semiotic resources delivered through the captions, main text, and signs and symbols layered over the photographs themselves would do the work that is equivalent to the gestures in the lecture. For example, emphasizing the course of a river

in a photograph in a textbook would require the river to be colored differently than other detail in the photograph; arrows could be placed such that they point directly to the river, indicating its course. Captions and main texts would have to “talk” the reader through the photograph, both describing *what* there is to see and providing instruction *how* to look. That is, we should not assume that photographs are self-evident but provide, textually or gesturally descriptions and instructions that assist first-time “readers” in deconstructing the image.

Similarly, *highlighting*, *outlining*, and *pointing to* something in a photograph in a textbook would be made possible through the use of color schemes, co-deployed with signs and symbols, such as arrows and geometric shapes, to ensure that the reader is able to appreciate all the information provided during his/her work of interpretation. *Adding* something to a photograph in a textbook corresponds to the way in which a lecturer can add something to a photograph in a lecture situation; but this may be a considerable challenge to textbook authors and producers. Adding an event to the photograph, such as for example, when the lecturer gestures over the photograph to add an oil spill, as one of the lecturers did in my second study, would require the co-deployment of a drawing over the photograph itself. Therefore, the drawing, constituting a different type of visual information, layered on top of the photograph, would allow readers to visualize something else happening in the photograph that was actually not depicted by it. It is important to emphasize, however, that the texts accompanying this assemblage of photograph and drawings would have to be very explicit in guiding the reader through the photograph and drawings, as excess of visual information without the proper written guidance would be very confusing.

Although the reproduction in textbooks of some of the various functions that gestures have in relation to photographs in lectures could be made possible, the use of projected photographs may be preferable to printed photographs. The contribution of speech and gestures dramatically increase the semiotic resources available to the audience for interpreting the photograph. This increase is much more accentuated than any other assemblage of semiotic resources that could be used in textbooks for the aim of replicating the effect of the gestures.

Considering some of the difficulties the students experienced during the interpretation of photographs—as I reported them in Chapter 4 of this thesis—the alternative of photographs projected on the wall and a speaker talking and gesturing over and about them may have facilitated their interpretations. For instance, when students tried to identify the orchid in the photograph and failed or had great difficulty in doing so even after having read the caption that accompanied this photograph, a simple gesture of pointing to the orchid or outlining it would have solved the problem. Similarly, the projection of the lichen photograph against a wall—allowing a lecturer to gesture over and about it—would minimize the effects of decontextualization. The lecturer would be able to outline the lichens and thereby make them salient figure. Another pointing gesture would outline the background against which the figure has to stand to do the pedagogical work that it is supposed to do: distinguishing lichens from everything else.

The results of my first and third studies complement, confirm, and reinforce each other. Together, the two studies showed that the simultaneous use of multiple and diverse semiotic resources has a greater potential for helping students to interpret photographs and associate them with texts, thus increasing the probabilities that they will in fact

understand the scientific concepts presented. My suggestions for textbook authors are drawn from the results of these two studies, and are presented in the next section.

Photographs are powerful visual resources for providing information. At the same time, different interpretations are made possible, as my first study showed, and are enacted in practice by students, as my third study showed. Precisely those aspects that make photographs the most realistic static depiction of the world, the contextualizing details that make the ground against which the relevant objects and events stand as figure, are also the main causes for their ambiguity. My first and second study showed that textbooks and lectures can make available a range of semiotic resources that constrain possible meanings of photographs. My third study showed the necessity for the simultaneous use of diverse semiotic resources in addition to the photographs to facilitate students' interpretative work. That is, as a set, my three studies make salient important factors to be considered in the use of photographs for pedagogical purposes in the teaching and learning science.

5.3. Implications

My work has direct implications for textbook authors, as well as for teaching approaches in classroom. The various findings and recommendations present in the three articles that constitute this thesis are of considerable interest for textbooks authors and teachers.

5.3.1. Textbook Authors

Textbook authors could benefit from my analysis of the semiotic resources made available to the readers of illustrated textbooks when they are studying the photographs and texts. The various recommendations about how photographs and texts should be used

in textbooks certainly constitute useful information for textbook authors and publishers as well. Although every photograph has the function of calling readers' attention, not any one photograph by itself is suitable for teaching a scientific concept in a textbook. Several features must be carefully regarded during the selection of a photograph, as to guarantee that this particular photograph will achieve its pedagogical function in the textbook.

Special attention should be given to the selection of the photographs themselves. The photographs should be framed, that is, the relevant object or phenomenon should be centralized in the photograph, perhaps even having the background of the photograph slightly out of focus, so the central, more focused object would immediately come to the foreground. Whenever possible, neutral backgrounds should be used, as long as it does not imply in the decontextualization of the object or phenomenon represented in the photograph.

The caption of the photograph should first of all name the relevant object or phenomenon represented in the photograph. Furthermore, the caption should provide enough information about this object or phenomenon as to help the reader to unmistakably identify it in the photograph. The caption should guide the readers through the reading of the photograph, helping them to distinguish the relevant object or phenomenon from the background, and, at the same time, allowing the reader to associate photograph and text. Complementary captions proved to function better than explanatory or illustrative captions in doing just that.

My studies also suggest that textbooks ought to make available a conjunction of semiotic resources to the readers in order to assure that they would be able to

appropriately interpret photographs when learning about a scientific concept. Because written texts are more limited than verbal texts, the work of interpreting photographs in a textbook is facilitated when a variety of semiotic resources are available. For example, in an ideal situation, a pair or series of photographs depicting an object or phenomenon should present a clear and objective main text that explains the concept to which the photograph refers. The indexical reference to the photograph should be placed immediately after the first time the object or phenomenon depicted in the photograph is mentioned in the main text. Also, the indexical reference should clearly direct the reader to the photograph, as for example, when it reads “refer to figure 1”, or “as you can see in figure 1.”

Similarly, the associated texts as well as other semiotic resources co-deployed with photographs in a textbook were carefully addressed during my research. Appropriate captions, the proper use of indexical references and other semiotic resources, and their arrangement and structure on the page of the textbook are important factors that must be more attentively regarded by textbook authors and publishers. The lack of semiotic resources that could have been made available on the photograph itself (e.g., color schemes, arrows, etc.), certainly increases the difficulties in interpreting photographs.

If the photographs selected for a publication are full of (gratuitous) detail in the background, the use of color schemes, arrows, words, and so on, directly laid on the photographs themselves is advised. They contribute to constraining the possibilities of diverse interpretations of photographs. Taken together, these semiotic resources ensure that the possibilities of misinterpretation of the photographs would be greatly reduced, allowing the readers to associate photographs and text, and maximizing the pedagogical

potential of photographs in teaching a scientific concept. Various and different semiotic resources should be employed together in the textbooks to help the readers in their work of interpretation of photographs while reading a text dealing with a scientific concept.

5.3.2. Teachers

Teachers could also greatly benefit from the results of my research, both when teaching and when selecting curriculum materials for their classes. For instance, if teachers believe photographs have a pedagogical function in teaching a scientific concept, they will be able to identify the pedagogical potential of photographs in textbooks, and make a better use of them, helping students to interpret these photographs and connect them with the texts. Teachers can help students to interpret photographs and associate them with texts when they project the photographs on the wall, talking, and gesturing over and about the photographs. Teachers' gestures in such situations function as powerful semiotic resources that do more than only guide students through the interpretation of the photographs, they also transform the photographs themselves, opening up new dimensions in these photographs, allowing them to fully achieve their potential as pedagogical resources.

When analyzing the multiple photographs about camouflage, the students themselves used gestures as a resource for helping them understand these photographs. Thus, some students covered the second photograph of the camouflage sequence so that they were only looking at two photographs pertinent to this concept. Their gesture was hiding the photograph that confused the interpretation of the series as an instance of camouflage. In a classroom situation, with these photographs projected on the wall, teacher's gestures could help students' interpretation and understanding of the concept of

camouflage. Teachers could also help disambiguate the two different concepts, camouflage and adaptation, present in this sequence of photographs. Finally, teachers could call on students to provide their own readings, pointing out those parts of a photograph salient to them.

BIBLIOGRAPHY

- Amabis, J. M., & Martho, G. R. (2001). *Fundamentos da biologia moderna* [Fundamentals of modern biology]. Sao Paulo, Brazil: Moderna.
- American Association for the Advancement of Science (2000, June 27). Big biology books fail to convey big ideas, reports AAAS's Project 2061. News release available at URL <http://www.project2061.org/newsinfo/press/rl000627.htm> (Viewed November 30, 2002).
- American Heritage® Dictionary of the English Language Fourth Edition (2000). New York: Houghton Mifflin Company.
- Bastide, F. (1990). The iconography of scientific texts: principles of analysis. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 187–229). Cambridge, MA: MIT Press.
- Bateson, G. (1972). *Steps to an ecology of mind*. New York: Ballantine.
- Bavelas, J. B., Chovil, N., Coates, L., & Roe, L. (1995). Gestures specialized for dialogue. *Personality and Social Psychology Bulletin*, 21, 394–405.
- Berger, J. (1972). *Ways of seeing*. London: Penguin Books.
- Bjelic, D. I. (1992). The praxiological validity of natural scientific practices as a criterion for identifying their unique social-object character: The case of the ‘authentication’ of Goethe’s morphological theorem. *Qualitative Sociology*, 15, 221–245.
- Bowen, G. M., & Roth, W.-M. (2002). Why students may not learn to interpret scientific inscriptions? *Research in Science Education*, 32, 303–327.
- Brown, J. S., & Duguid, P. (1992). Enacting design for the workplace. In P. S. Adler & T. A. Winograd (Eds.), *Usability: Turning technologies into tools* (pp. 164–197). New

York: Oxford University Press.

Church, R. B., & Goldin-Meadow, S. (1996). Using the relationship between gesture and speech to capture transitions in learning. *Cognition*, 23, 43–71.

Derrida, J. (1981). *Dissemination*. Chicago: University of Chicago Press.

Derrida, J. (2001). *The work of mourning* (ed. P.-A. Brault & M. Naas). Chicago: University of Chicago Press.

Eco, U. (1984). *Semiotics and the philosophy of language*. Bloomington: Indiana University Press.

Egbert, M. M. (1996). Context-sensitivity in conversation: Eye gaze and the German repair initiator *bitte*? *Language in Society*, 25, 587–612.

Favaretto, J. A., & Mercadante, C. (2000). *Biologia* [Biology]. Sao Paulo, Brazil: Moderna.

Fraser, B. G., & Williams, D. D. (1998). Seasonal boundary dynamics of a groundwater/surface water ecotone. *Ecology*, 79, 2019–2031.

Geertz, C. (1973). *The interpretation of cultures: Selected essays*. New York: Basic Books.

Good, R. (1993). Editorial: Science textbook analysis. *Journal of Research in Science Teaching*, 30, 619.

Goodwin, C. (1994). Professional vision. *American Anthropologist*, 96, 606–633.

Goodwin, C. (1995). Seeing in depth. *Social Studies of Science*, 25, 237–274.

Guba, E., & Lincoln, Y. (1989). *Fourth generation evaluation*. Beverly Hills, CA: Sage.

Hanks, W. F. (1992). The indexical ground of deictic reference. In A. Duranti & C.

Goodwin (Eds.), *Rethinking context: Language as an interactive phenomenon* (pp.

- 43–76). New York: Cambridge University Press.
- Haviland, J. B. (1993). Anchoring, iconicity, and orientation in Guugu Yimithirr pointing gestures. *Journal of Linguistic Anthropology*, 3, 3–45.
- Henderson, K. (1991). Flexible sketches and inflexible data bases: Visual communication, conscription devices, and boundary objects in design engineering. *Science, Technology, & Human Values*, 16, 448–473.
- Hutchinson (1992). *Concise encyclopedic dictionary*. London, England: Helicon/ Oxford University.
- Il'enkov, E. (1977). *Dialectical logic: Essays in its history and theory* (Transl. by H. Campbell Creighton). Moscow: Progress.
- Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences*, 4, 39–103.
- Kelly, S. D., Barr, D. J., Church, R. B., & Lynch, K. (1999). Offering a hand to pragmatic understanding: The role of speech and gesture in comprehension and memory. *Journal of Memory and Language*, 40, 577–592.
- Kieft, T. L., White, C. S., Loftin, S. R., Aguilar, R., Craig, J. A., & Skaar, D. A. (1998). Temporal dynamics in soil carbon and nitrogen resources at a grassland-shrubland ecotone. *Ecology*, 79, 671–683.
- Knorr-Cetina, K. D., & Amann, K. (1990). Image dissection in natural scientific inquiry. *Science, Technology, & Human Values*, 15, 259–283.
- Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind*. Chicago: University of Chicago Press.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through*

- society*. Milton Keynes: Open University Press.
- Latour, B. (1993). *La clef de Berlin et autres leçons d'un amateur de sciences* [The key to Berlin and other lessons of a science lover]. Paris: Éditions la Découverte.
- Latour, B. (1999). *Pandora's hope: Essays on the reality of science studies*. Cambridge, MA: Harvard University Press.
- Law, J., & Lynch, M. (1990). Lists, field guides, and the descriptive organization of seeing: Birdwatching as an exemplary observational activity. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 267–299). Cambridge, MA: MIT Press.
- Lemke, J. L. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex Publishing.
- Lemke, J. L. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. R. Martin & R. Veel (Eds.), *Reading science* (pp. 87–113). London: Routledge.
- Lemke, J. L. (1999). Typological and topological meaning in diagnostic discourse. *Discourse Processes*, 27, 173–185.
- Livingston, E. (1995). *An anthropology of reading*. Bloomington: Indiana University Press.
- Lowe, R. K. (1999). Extracting information from an animation during complex visual learning. *European Journal of Psychology of Education*, 14, 225–244.
- Lynch, M., & Woolgar, S. (Eds.). (1990). *Representation in scientific practice*. Cambridge, MA: MIT Press.
- McNeill, D. (1985). So your think gesture are nonverbal? *Psychological Review*, 92, 350–371.

- McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago: University of Chicago Press.
- McNeill, D. (2002, May). *Gesture and language dialectic*. Paper presented at the conference “The Multimodality of Human Communication: Theories, Problems and Applications.” Toronto, Canada, May 3–5.
- Morrison, K. (1989). Some researchable recurrences in discipline-specific inquiry. In D. T. Helm, W. T. Anderson, A. J. Meehan, & A. W. Rawls (Eds.), *The interactional order: New direction in the study of social order* (pp. 141–158). New York: Irvington.
- Myers, G. (1990). Every picture tells a story: Illustrations in E. O. Wilson’s *Sociobiology*. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 231–265). Cambridge, MA: MIT Press.
- Myers, G. (1990). Every picture tells a story: Illustrations in E. O. Wilson’s *Sociobiology*. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 231–265). Cambridge, MA: MIT Press.
- National Academy of Science (1997). *Science for all children*. Washington, DC: Author.
- Ochs, E., Gonzales, P., & Jacoby, S. (1996). “When I come down I’m in the domain state”. Grammar and graphic representation in the interpretive activity of physicists. In E. Ochs, E. A. Schegloff, & S. A. Thompson (Eds.), *Interaction and grammar* (pp.328–369). New York: Cambridge University Press.
- Paulino, W. R. (2001). *Biologia: Serie novo ensino medio* [Biology: New high school series]. Sao Paulo, Brazil: Atica.
- Peeck, J. (1993). Increasing picture effects in learning from illustrated texts. *Learning*

and Instruction, 3, 227–238.

- Ralof, J. (2001, March 17). Why some schools may not want to go by the book. *Science News*, 159 (11). Available at URL <http://www.sciencenews.org/index.asp> (Viewed November 30, 2002)
- Ricœur, P. (1991). *From text to action: Essays in hermeneutics, II*. Evanston, IL: Northwestern University Press.
- Roth, W. -M., & McGinn, M. K. (1998). Inscriptions: Toward a theory of presenting as social practice. *Review of Educational Research*, 68, 35–59.
- Roth, W.-M., & Bowen, G. M. (1999a). Decalages in talk and gesture: Visual and verbal semiotics of ecology lectures. *Linguistics & Education*, 10, 335–358.
- Roth, W.-M., & Bowen, G. M. (1999b). Digitizing lizards or the topology of vision in ecological fieldwork. *Social Studies of Science*, 29, 719–764.
- Roth, W.-M., Bowen, G. M., & McGinn, M. K. (1999). Differences in graph-related practices between high school biology textbooks and scientific ecology journals. *Journal of Research in Science Teaching*, 36, 977–1019.
- Roth, W.-M., McGinn, M. K., Woszczyzna, C., & Boutonné, S. (1999). Differential participation during science conversations: The interaction of focal artifacts, social configuration, and physical arrangements. *The Journal of the Learning Sciences*, 8, 293–347.
- Roth, W.-M., & Lawless, D. V. (2002). When up is down and down is up: Body orientation, proximity, and gestures as resources. *Language in Society*, 31, 1–28.
- Schnotz, W., Picard, E., & Hron, A. (1993). How do successful and unsuccessful learners use texts and graphics? *Learning and Instruction*, 3, 181–199.

- Schoultz, J., Säljö, R., & Wyndhamn, J. (2001). Heavenly talk: Discourse, artifacts, and children's understanding of elementary astronomy. *Human Development, 44*, 103–118.
- Snow, R. E. (1997). Aptitudes and symbol systems in adaptive classroom teaching. *Phi Delta Kappan, 78*, 354–360.
- Soares, J. L. (1999). *Biologia* [Biology]. Sao Paulo, Brazil: Scipione.
- Ueno, N., & Arimoto, N. (1993). Learning physics by expanding the metacontext of phenomena. *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 15*, 53–63.
- Wittgenstein, L. (1994/1958). *Philosophical investigations* (3rd ed.). New York: Macmillan.

VITA

Surname: Pozzer-Ardenghi

Given Names: Lilian

Place of Birth: Santa Maria, Rio Grande do Sul, Brazil

Educational Institutions Attended:

University of Victoria	2001-2003
Universidade Federal de Santa Maria	1996-2000

Degrees Awarded:

Licentiate in Biological Sciences	Universidade Federal de Santa Maria	2000
-----------------------------------	-------------------------------------	------

Publications:

Pozzer, L. L. & Roth, W.-M. (in press). Prevalence, function and structure of photographs in high school biology textbooks. *Journal of Research in Science Teaching*.

Pozzer-Ardenghi, L. & Roth, W.-M. (2003). Photographs in lectures: gestures and body orientation as meaning-making resources. In: W.-M. Roth (ed.), *CONNECTIONS' 03* (pp. 1–30). Victoria, BC, University of Victoria.

UNIVERSITY OF VICTORIA PARTIAL COPYRIGHT LICENSE

I hereby grant the right to lend my thesis to users of the University of Victoria Library, and to make single copies only for such users or in response to a request from the Library of any other university, or similar institution, on its behalf or for one of its users. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by me or a member of the University designated by me. It is understood that copying or publication of this thesis for financial gain by the University of Victoria shall not be allowed without my written permission.

Title of thesis:

Making Sense of Photographs in Science Textbooks and Lectures

Author



Lilian Pozzer-Ardenghi

June 25, 2003



University of Victoria - Human Research Ethics Committee

Certificate of Approval

<u>Principal Investigator</u> Dr. Wolff-Michael Roth Faculty	<u>Department/School</u> EDCD	<u>Supervisor</u>	
<u>Co-Investigator(s):</u> Leanna Boyer, Research Assistant, EDCD, UVic Lilian Leivas Pozzer, MA, EDCD, UVic Lyubov Laroche, Research Assistant, EDCD, UVic			
<u>Title:</u> Learning in Heterogeneous and Overlapping Knowledge-Building Communities			
<u>Project No.</u> 177-02	<u>Approval Date</u> 07-Jun-02	<u>Start Date</u> 01-Apr-99	<u>End Date</u> 06-Jun-03

Certification

This is to certify that the University of Victoria Ethics Review Committee on Research and other Activities Involving Human Subjects has examined the research proposal and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.



J. Howard Brunt
Associate Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions/minor amendments may be granted upon receipt of "Request for Continuing Review or Amendment of an Approved Project" form.

177-02 Roth, Wolff-Michael

webmail @uvic.ca



Folder: INBOX
Action: READ MESSAGE

Select a folder to save message in:

Juliany Maizato -

SAVE MESSAGE

From: "Juliany Maizato - Direitos Autorais" <juliany.maizato@moderna.com.br>

ADD to ADDRESSES

To: <llpozzzer@uvic.ca>

Date: Mon, 25 Feb 2002 08:24:01 -0300

Subject: En: Autorização - Biologia e Fundamentos da Biologia

Attachments:

Cara Lilian,

Encaminho a mensagem enviada em 24/01/2002 informando nossa resposta quanto a autorização solicitada para a utilização de trechos dos livros de Biologia.

Se você tiver mais alguma dúvida, por favor contate-nos.

Atenciosamente,

Juliany

----- Original Message -----

From: Juliany Maizato - Direitos Autorais

<juliany.maizato@moderna.com.br>

To: <llpozzzer@uvic.ca>

Cc: Rosa Maria Rodrigues - Direitos Autorais <rosa@moderna.com.br>

Sent: Thursday, January 24, 2002 3:54 PM

Subject: Re: Autorização - Biologia e Fundamentos da Biologia

> Cara Lilian,

>

> Informamos que autorizamos a utilização dos trechos editados e publicados pela Editora Moderna, conforme segue abaixo:

>

> - Páginas 16, 41, 63 e 64 da obra "Fundamentos da Biologia Moderna" de José Mariano Amabis e Gilberto Rodrigues Martho;
> - Páginas 46 e 61 da obra "Biologia - Volume Único" de José Arnaldo Favaretto e Clarinda Mercadante.

>

> Solicitamos que os devidos créditos devem constar no referido trabalho

>

> agradecemos desde já o envio de 1 exemplar para nosso conhecimento e arquivo. Pedimos atenção especial para a utilização das fotografias que representam as formações fitogeográficas do Brasil do livro do Amabis e Martho, pois os créditos devem ser dados aos fotógrafos.

>

> Os autores Amabis e Martho ficaram muito felizes pela sua escolha e deixaram o e-mail para que você entre em contato com eles caso queira
> Martho
> e-mail: martho@originet.com.br

>

> Bem, se você tiver maiores questionamentos, não hesite em nos contatar.

>

> Julianny

> ----- Original Message -----

> From: <llpozzer@uvic.ca>

> To: <juliany.maizato@moderna.com.br>

> Sent: Thursday, January 17, 2002 5:04 PM

> Subject: Re: Autorização - Biologia e Fundamentos da Biologia

> > Bom dia Julianny!

> > Muito obrigada por sua pronta resposta!

> > Em meu trabalho, utilizaria as seguintes paginas:

> > Amabis & Martho: 16; 41; 63; 64.

> > Favaretto & Mercadante: 46; 61.

> > Entretanto, gostaria de esclarecer que nao reproduzirei essas

paginas

por

> completo; ou seja, apenas utilizarei alguns elementos presentes nessas

> paginas, como, por exemplo, fotografias e alguns paragrafos do texto.

Todo

o

> material utilizado sera traduzido para o ingles (livre-traducao, por

nim

> mesma), uma vez que meu trabalho de pesquisa esta sendo desenvolvido

aqui

no

> Canada.

> >

> > Infelizmente nao posso ser muito mais especifica sobre a

utilizacao

desse

> material, a fim de salva-guardar meu trabalho de pesquisa. No entanto,

posso

> afirmar que todo e qualquer resultado apresentado em meu trabalho nao

> denegrira e/ou prejudicara em absoluto o autor ou a editora da obra. A

> escolha dessas duas obras se fez devido a larga utilizacao das mesmas

na

> cidade onde residia antes de iniciar meu mestrado (Santa Maria, Rio

Grande

> do Sul). De qualquer forma, ficarei muito satisfeita em enviar-lhe uma

copia

> de meu artigo, quando este for publicado.

> >

> > Sobre a revista na qual pretendo publicar meu artigo, trata-se de

uma

> publicacao internacional, muito conhecida e seria, consultada

principalmente

> pela comunidade universitaria relacionada a Educacao. Como ainda nao

obtive

> resposta final, referente a publicacao de meu artigo nessa revista,

ainda

> nao estou apta a lhe fornecer maiores informacoes. Porem, necessito da

artigo.
>
>
> > O site da revista Journal of Research in Science Teaching e o
seguinte:
> <http://www3.interscience.wiley.com/cgi-bin/jtoc?ID1817>
> > Nesse site voce podera encontrar as ultimas edicoes da revista e
algumas
> outras informacoes.
>
>
> > Muito obrigada por sua atencao.
>
>
> > Atenciosamente,
> > Lilian L. Pozzer.
>

Show Message Headers:

Interpret HTML:

CHANGE PROPERTIES

Select Message to View

Jullany Ma: En: Autorização

SHOW MESSAGE



Index	Compose	Address	Options	Folders	Help	Logout
-----------------------	-------------------------	-------------------------	-------------------------	-------------------------	----------------------	------------------------

webmail
@uvic.ca



Folder: INBOX
Action: READ MESSAGE

Select a folder to
save message in:

elba.gomes@atica.c

SAVE MESSAGE

From: elba.gomes@atica.com.br
To: llpozzzer@uvic.ca
Date: Tue, 5 Feb 2002 16:48:14 -0200
Subject: Re: Autorização
Attachments:

ADD to ADDRESSES

Prezada Lilian Pozzer,
com referência aos seus e-mails de 16 e 17/01/02, autorizamos a reprodução das páginas 348, 372, 377 e 387 do livro Novo Ensino Médio - Biologia, de autoria de Wilson Roberto Paulino, em seu projeto de pesquisa para ser utilizado pela comunidade universitária relacionada à Educação.

Cordialmente,
Elba Gomes
Direitos Autorais
e-mail: elba.gomes@atica.com.br
Tel.: (0XX11) 3346-3315
llpozzzer@uvic.ca

Para:
elba.gomes@atica.com.br
25/01/02 17:16 cc:
Responder a Assunto: Re: Autorização
llpozzzer

Bom dia Elba!
Tudo bem, esperarei sua resposta em fevereiro!
Muito obrigada pela atencao!
Atenciosamente,
Lilian L. Pozzer.

Show Message Headers:

Interpret HTML:

CHANGE PROPERTIES

Select Message to View

elba.gomes: Re: Autorizaç

SHOW MESSAGE

webmail
@UVIC.ca



Folder: INBOX
Action: READ MESSAGE

Select a folder to
save message in:

sintia.mattar@scip

SAVE MESSAGE

From: sintia.mattar@scipione.com.br
To: llpozzaer@uvic.ca
Date: Tue, 22 Jan 2002 16:56:49 -0200
Subject: Re: Biologia, de J.L. Soares - Volume Único
Attachments:

ADD to ADDRESSES

Prezada Senhora:

Em atendimento à sua solicitação, autorizamos a utilização, tanto para reprodução, quanto para tradução, dos textos constantes das páginas nºs 308, 311, 328 e 329 da referida obra. Ressaltamos, entretanto, que não podemos conceder qualquer licença no que se refere às ilustrações e fotos, já que não somos os titulares dos direitos sobre as mesmas. Agradecemos por sua compreensão e permanecemos a seu inteiro dispor. Atenciosamente.

Sintia Mattar
Editorial - Direitos Autorais
Fone: 3241-2255 R. 281
llpozzaer@uvic.ca

To: sintia.mattar@scipione.com.br

cc: 22/01/02 Subject: Re: Biologia, de J.L.

Soares - Volume Único
04:45
Please respond to llpozzaer

Prezada Sr. Sintia Mattar.
Muito obrigada pela sua atencao.
Como parte do meu trabalho de pesquisa, utilizarei partes das seguintes paginas da referida obra: 308; 311; 328; 329.
Gostaria de especificar tambem que os textos extraídos dessas paginas serao traduzidos para a lingua inglesa (livre-traducao, por mim mesma), e que nao utilizarei reproducoes "na integra" de nenhuma das paginas citadas, somente alguns elementos, como paragrafos ou frases dos textos e figuras.
Qualquer informacao adicional que necessitares, estarei a disposicao.
Muito obrigada!
Atenciosamente,
Lilian L. Pozzer.

Show Message Headers:

Interpret HTML:

CHANGE PROPERTIES