ABSTRACT: In some contexts, a photograph may be worth a thousand words. Previous research revealed a dialectical character of photographs: they simultaneously lack determinacy and exhibit an excess of meaning. The purpose of this study was to understand how, under this condition, high school students interpret 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 perceived was in part a function of the presence of caption and main text; these texts not only described what could be seen but also taught students how to look at photographs. We conclude that high school students not only need to develop subject matter literacy but also a literacy concerning photographs to fully understand their textbooks.

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 currently are. 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 make significant contributions to textbooks because of their potential for improving students’ retention of associated text (Peeck, 1993). Yet there is very little research investigating the pedagogical role of photographs in school science: neither the psychology of cognition and learning (Schnotz, Picard, & Hron, 1993) nor science education research have paid much attention to this topic (Pozzer & Roth, 2003). What complicates the issue is that photographs may be worth a thousand words, but on their own, they mean very little (Wittgenstein, 1994/1958). They give rise to innumerable, different interpretations because, as our introductory quote articulates, their meaning emerges from the dialectic relation between the photographer’s way of seeing and the perceptions 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 arise (Bjelic, 1992). What then do high school students perceive when they look at photographic images in biology textbooks? How do they use other meaning-making resources that a text makes available when they want to understand the things that the photograph is about? The present study was designed to find out how Brazilian high school students understand photographs that are accompanied by different amounts and types of co-text (caption, main text). Our research questions included: (a) What is the role of semiotic resources co-deployed with photographs? (b) Do students “read” photographs when they are studying a text? (c) Do students’ interpretations of photographs change when they are provided with additional text? (d) How do interpretations change when other meaning-making resources are provided? and (e) Is there a difference in the way students interpret multiple versus single photographs?
Background

School science is dominated by textbook-oriented approaches to teaching and learning (NAS, 1997). Textbooks are therefore the most important resources in students’ learning of science. At the same time, science textbooks use a large number of photographs (Roth et al., 1999); photographs therefore ought to attract science educators’ attention to develop their potential as meaning-making resource to the fullest.

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 that photographs are often taken as mechanical records of reality; they are thought of as recordings “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, guarantors of truthful representation (Myers, 1990). All of these underlying assumptions are based on the similitude of photographs with the objects they depict. But even such similitude is a cultural-historical achievement that individuals have to reproduce and therefore cannot be taken for granted (Eco, 1984). The photograph can achieve its powerful role as representation of the real world only through the reader’s work of reading, that is, the viewer’s reproduction of the narrative and perceptual order of the image (Morrison, 1989).

How inscriptions are deployed in textbooks plays an important role in students’ school science experience. 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, captured in the popular adage that a picture is worth ten thousand words; yet in everyday classroom life, images are often used as adjuncts that merely serve decorative purposes. On the other
hand, students prefer textbooks that contain illustrations; yet in learning, they appear to pay only scant attention to pictorial information. 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 (Pozzer & Roth, 2003). To understand the effect of photographs in learning, we 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. We analyze (a) the meaning-making resources that students discover and draw on while studying images and associated texts and (b) how students make use of these resources to achieve understanding.

**Study Design**

This study is part of the principal author’s master’s thesis, concerned with understanding the pedagogical function of photographs in school science textbooks. Two previous studies 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 we therefore interviewed students from different grade levels, showing them photographs from biology textbooks and asking them to articulate what the photographs meant to them. We extracted the photographs from the ecology-related chapters of Brazilian high school biology textbooks that had been analyzed and categorized in a previous study (Author, 2003).

**Selecting the Students**

To investigate photographs and their relation to captions and main text during interpretation, students from two distinct groups
Students’ Interpretation of Photographs

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 was thought to allow us 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 normally taught in a general science course that students attend in fifth or sixth grade. An expanded ecology curriculum is taught as part of the biology curriculum while students attend grades ten or eleven, depending on the school.

A total of twelve students, six from each of the two groups were interviewed. The principal investigator invited students during one of their courses and accepted them into the study on a first-come-first serve basis. In this way, the first participant group included five ninth-grade students, three females and two males, and one eighth-grade male student. The group of students who had prior instruction in ecology consisted of five eleventh-grade students, four males and one female, and one tenth-grade female student. Students attended either private or public school. All twelve students were from a middle-class background. The interviews were videotaped using a digital camcorder and subsequently transcribed; pseudonyms are used throughout this study.

Selecting the Photographs

Four photographs were used during the interview based on our previously published study of the different functions they played as meaning-making resources (Pozzer & Roth, 2003). The following distinctions were addressed in the selection of the photographs: (a) there were both single and multiple photographs; (b) some photographs were referred to in the text others were not (i.e., incidence and placement of a feature such as “Fig. 30.3”); and (c) all four major categories of photographs identified in our previous study had to be represented. Table 1 provides a summary of the four categories of photographs according to their function in relation to caption and main text. We began by selecting a variety of
photographs that could address one or more of these aspects; we then discussed each photograph, which led us to further refine this selection until we agreed upon four photographs as meeting the three aspects.

Our first photograph, which we refer to as the photograph of the orchid, represents a single photograph, is associated with an indexical reference appropriately placed in the main text, and represents *illustrative* photographs. (Figure 1). Our previous study suggested that the photograph has the potential to give rise to misinterpretations due to the enormous amount of details present in the photograph and due to 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. Furthermore, this photograph was one amongst very few photographs that presented some kind of semiotic resource directly placed on the photograph itself (in this case, the word *Orquídea* [Portuguese, “orchid”] in the bottom right corner of the photograph).

The second photograph was a single photograph and exemplified *decorative* photographs (Figure 2); that is, it lacked caption and indexical reference in the text. For the interview, we repro-

Table 1 *Categories of photographs*

<table>
<thead>
<tr>
<th>Categories of Photographs</th>
<th>Description</th>
<th>Representative Photograph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decorative</td>
<td>Photographs without a caption and deictic reference in the text.</td>
<td>Caterpillar</td>
</tr>
<tr>
<td>Illustrative</td>
<td>Photographs with a caption that names the object/phenomenon represented in the photograph. No additional information is available.</td>
<td>Orchid</td>
</tr>
<tr>
<td>Explanatory</td>
<td>Photographs with a caption that names the object/phenomenon represented in the photograph, and provides an explanation or classification of this object/phenomenon.</td>
<td>Lichens</td>
</tr>
<tr>
<td>Complementary</td>
<td>Photographs with a caption that names the object/phenomena represented in the photograph, and provides new information about this object/phenomena, not available in the main text associated to this photograph.</td>
<td>Camouflage</td>
</tr>
</tbody>
</table>
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 an 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 1** Photograph of the Orchid. Reproduction of the maintext 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.

duced the entire page where this photograph appeared, leaving it to the participants to decide whether the text pertained to the photograph or not. The chosen photograph will be referred to as the photograph of the caterpillar. The third item consisted of a series of three photographs; the main text did not refer to them. It represented complementary photographs (Figure 3, on the next page). These photographs deal with the concept of camouflage. The fourth and final photograph (Figure 4, on page 11) was a single photograph to which the main text referred in an appropriate manner; it represented explanatory photographs. The topic of the text was mutualism, and the photograph presents lichens as ex-
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

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

Figure 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.

samples of mutualistic associations. Developing Strategies to Conduct the Interviews

Before the interview started, the interviewer explained the research project in general terms to each interviewee and provided an opportunity for questions. The interviewer then explained the basic structure of the interview. The interviewees were instructed to answer the questions in an appropriate voice volume (the interviewer would ask them to repeat if the voice volume was too low), and they were encouraged to think aloud while looking at the photographs, describing what they were thinking. The interviewer asked the interviewees to read aloud any parts of the text that they were attending to.
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 3 Photographs of Camouflage. Reproduction of the maintext 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.

Our major interest in this study was related to the role of photographs, captions and texts in the actual process of reading a textbook. We therefore decided to make use of two different strategies that allowed us to better investigate these roles. We presented photographs to the students in the following sequence: First, the interviewee received a colored copy of the photograph of the orchid. No caption or text was given to the interviewee at this point. The interviewer then asked the interviewee to talk about the photograph (see interview guideline in Appendix 1). Second, the interviewer provided the interviewee with the captions that originally accompanied the photograph of the orchid. The interviewee
**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, giving 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](image-url) Macroscopic aspect of lichens.

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

**Figure 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.

was asked to read the caption aloud. New questions were asked. Finally, the interviewee received the main text associated to this figure, and was asked to read it aloud. More questions were then asked.

Students were then presented with the caterpillar photograph. In this case, we provided students with a colored copy of the entire page of the textbook where this photograph originally appeared. The students began reading the text or commenting on the photograph. When the students had completed, the interviewer asked additional questions from the interview protocol. Camouflage photographs were presented next. All three photographs
were presented as a set following the same strategy as with the orchid photograph. Finally, the lichens photograph was presented. In this case, students were provided with the reproduction of the entire page of the textbook from where we had culled it. Again, students could either read the texts accompanying this photograph or comment on the photograph.

By presenting the photograph of the orchid and the multiple photographs about camouflage according to the first strategy we described, we 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 complement one another: in this case, photograph, caption, and main text. While some students read the entire main text without interruption other students commented while reading the texts. The intention of our second strategy (photographs of caterpillar and lichens) was to present the photographs as they might appear in the textbook, allowing us to study the meaning-making resources that students “naturally” identified and how they used them in their interpretations.

Even though we developed an interview guide and were careful to avoid questions that could direct the interviewees towards particular features in the photograph, 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 (Suchman & Jordan, 1990). If students used some such aspect in their reasoning, we would expect that it directly or indirectly shaped the answers given. We address this particular issue and provide some examples of it throughout this article.

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, we began our analysis following the principles of Interaction Analysis (Jordan & Henderson, 1995). We read the transcripts individually, identifying relevant issues. We then met to discuss our individual constructions and to test them in the entire database. After our first meeting, we decided to focus our analysis at 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 completed. Each interview segment was analyzed following this procedure. An overall analysis of the entire interview was conducted at the end of the segment analysis.

Findings

Through our 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. The most important aspects derived from our analysis are (a) the changes in how students perceived photographs when additional text was provided, (b) the work of reading when texts and photographs were provided simultaneously, and (c) the influence of the interview context and prior knowledge/experience on students’ interpretations. In the following three subsections, we articulate and provide data for each of these aspects.

Surplus of Meaning from Additional Textual Resources

“The picture helps to understand the text as much as the text helps to understand the picture.”

(Faith, grade 10)

In this study, we were interested to find out how students might change their interpretations of photographs when additional textual resources were provided. Here, these consisted in the captions and main texts that had accompanied the photographs in the original textbooks. In this section, we present students’ responses to the sequential addition of captions and main texts, respectively.
Photographs

The students’ immediate reactions to the 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 an 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, during their observation of the photographs, the students pointed out many other aspects of the photographs. In 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). 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. Six students mentioned a plant, which we infer as being the orchid in the picture (one student referred to “parasite plant”, and another student used the term “fern”). Six students actually mentioned the presence of an orchid in the photograph. When asked about what could be the topic of this photograph, three students suggested that the photograph represented “many trees.” Four students mentioned the central tree as the topic of this photograph, whereas five students identified the topic as being the orchid. That is, rather than seeing the photograph as an concrete example of mutualism, which it represented in the textbook, the
predominant perceptual feature that students highlighted were the trees, not the relationship between the central tree and the orchid.

In a similar way, students identified many different entities in the photographs that represented camouflage: some students \((n = 5)\) 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). Almost all students \((n = 10)\) attempted to describe each photograph separately, emphasizing differences between the birds, the environments and/or the seasons represented in the three photographs. That is, rather than seeing in the series of photographs a concrete example of camouflage, students identified a variety of other features.

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, as 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, instead, perceived the changes in the photographs, the differences in the environment and the differences in the plumage of the bird; half of the students \((n = 6)\) 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.

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.\(^1\) 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.

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 variations between 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

\(^{1}\) 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.
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 on the very object that it is trying to depict, the same photograph can be used for very different and even opposite purposes (Lee & Roth, 2001), and the attention can be drawn to any detail, other than the one that seems to be the focal point in the photograph. In this case, however, we 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.

**Captions**

After pointing out several aspects of the photographs, the students claimed there was nothing else to be pointed out. At this time, then, the interviewer presented the students with the captions of the photographs. These constitute additional semiotic (meaning-making) resources that might alter how the students perceive and therefore interpret the photographs (given 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, used deictic gestures (pointing) to identify the epiphyte plant in the photograph. Besides two students who already knew orchids from nature, the other students \( (n = 7) \) proposed the or-
chid as the epiphyte plant in the photograph because it was the most focused or centralized object in the photograph: “Because it is the most visible one, the one that is more like, like in the middle” (Ruth, grade 11), “Because that’s what more focused, together with the tree” (Andy, grade 9), “I don’t know, it’s showing them a lot” (Fran, grade 9), and “because it is the one that is more focused, more visualized I think, more apparent” (Adam, grade 11).

Reading the caption, the students focused their attention to a specific detail in the photograph, in this case, a plant. Lacking further resources in the caption that could help them to identify the epiphyte plant on this photograph, the students relied on other semiotic resources, made available directly on the photograph itself, such as, for example, differences in focus and alignment of the objects depicted.

This photograph had been classified as illustrative, because its caption provides only a name for the object or phenomenon the photograph is about (Pozzer & Roth, 2003). There was little else in the caption that might have helped 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 thought the epiphyte plant was the fungus on the branches of the central tree. This confusion is justified, insofar as the photograph lends itself as an illustration of lichens or another plants as much as it does 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 further resources 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 9) was a good example of how this procedure was enacted. 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 was 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 separated “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 (camouflage), however, students’ reactions after reading the caption were rather different than in the previous situation. 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 ani-
mal. 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 than 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, namely, that a white bird blends with a similar environment during winter time, and that, by changing its plumage, it also blends with the dry vegetation during summer time.

However, this particular series of photographs and its associated caption reveal also a problematic dimension. The photographs and caption provide not only instances of a bird camouflaged against the environment, but it also presents a temporal sequence, on which the bird changes plumage according to the seasons, as the environment also changes. After reading the caption, three students described the series as presenting camouflage, half of the students (n = 6) referred to the changes the bird and/or the environment undergo, and three students suggested the series represented both events. An important part of the confusion was centered on the second photograph; three students even said that the bird in this second photograph was not well camouflaged. Five 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 at least the temporal-sequential nature of this series of photographs.

The students did not make sense of the second photograph in the context of the concept of camouflage presented by the caption.
The students demonstrated that 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. This 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 seasonal changes insofar as, in describing the photographs, it emphasizes these changes, while also stating that “This is a good example of camouflage.” The caption refers at the same time to both events of camouflage and seasonal changes, without however helping the reader to identify the two different events represented in these photographs.

**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. They were, then, able to identify the leaves on the central tree as belonging to the orchid, although one student still demonstrated to have doubts about it, “I don’t know what is the orchid, what is the bromeliad but, there are plants here in the trunk of the trees, here there is one, see?” (Fran, grade 9).

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 does not refer to the seasonal changes undergone by the bird. After reading the main text, ten students thought the topic of the photographs was camouflage but two students said the topic of these photographs was the seasonal changes on the plumage of the bird: “[These pictures] it’s about European partridges, showing them changing their plumage in different seasons” (Fran, grade 9) and “It’s about what place each species inhabits? ... When it changes the season, the same bird starts to change the color of the feathers” (Ruth, grade 9).

The main text and the caption cannot assure that students will actually interpret the photograph in the intended way. Alternative readings of the text can occur, as for example, in the case of a student (Gil, grade 9) who identified the orchid as being the epiphyte plant, and the host tree as being a bromeliad. In this case, the alternative reading 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 alternative reading of the text (and instead of or) accounts for the difference in interpretation 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: “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 (“inquilinism”). Yet this interaction is not visually available in the photograph. Rather, it shows how 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 weather the photograph presents an orchid or a bromeliad; it only states that these are examples of epiphyte plants. Although the student in this case read the text in an alternative way, 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.
The Work of Reading the Text and Photograph Simultaneously

“If you are interested in the picture, you will want to read what is beside it, or below it, or above it.”
(Cameron, grade 8)

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

Common Functions of Photographs

One of the aspects that became salient in our 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.

As they received the reproduced pages, ten students immediately said 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 lichen 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 (only five students actually stated that they were looking at the photograph). As Cameron (grade 8) 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 do help the students in identifying what the figure is about, the pedagogical role of photographs is increased.
Another aspect that emerged from our analysis is related to the importance of the context of the photographs for students’ work of interpretation. Concerning the caterpillar photograph, 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 students identified the animal in the photograph. However, other aspects were also identified in this photograph: two students made references to where or when this photograph was took, “in a closed space” (Andy, grade 9) or “at night” (Cameron, grade 8), because the background was dark. These two students also inferred other aspects of the photograph. Cameron said, “this is a small bug,” and Andy stated that, “it must stop to be able to eat.” We notice 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 said they were looking at the picture, without any further comment about it. The other seven students, although they clearly looked at the photograph (as can be seen on the videotapes), they did not comment on whatsoever 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) did not identify anything in the photograph, and therefore turned their attention to the text, searching for information that could help them to figure out what the photograph was all about. A small number of students ($n = 4$) 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 (by the author) desired interpretation of the photograph is jeopardized.

Comparing this situation with the one presented by the caterpillar photograph we note that in the latter case, students were immediately drawn to the photograph. Although they all read the text, they all did so after commenting on the photograph. This makes it plausible to assume that in the case of the lichen photograph, students did not know what it 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, almost all students ($n = 11$) 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 the way in which 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, goes into the work of interpreting this photograph in this manner. We assume, 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.
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 (Pozzer & Roth, 2003). Our 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 lichen 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.

There was no clear effect associated with the presence or absence of an indexical reference. 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 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, some students \( (n = 4) \) identified the text as a summary or an introduction of what would be presented in the chapter that followed, but one that could be substituted by another picture:

I think it [the picture] could be substituted by any other environment, insofar as it is the animal’s environment, you couldn’t put a horse in the sea, it wouldn’t be right. But a horse in the field, it could be. (Adam, grade 11)
If they show a man there or even a bigger animal with a smaller one by its side and with a smaller one yet, then it would show that the stronger would... this one here is good [the picture] but you could use another too, maybe there are some other that would show it better. (Carol, grade 11)

The majority of students (n = 8) 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: “What [the picture] is aiming to show, the meaning of it, I don’t think I understand” (Brian, grade 11) and “I think that it doesn’t have anything to do with the text” (Faith, grade 10).

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 by the students as possible topics for the photograph, as an attempt to link photograph and text.

We can understand what happened in this situation in terms of authentication (Bjelic, 1992). In this process, a photograph is viewed as evidence supporting the text, in fact, because of its life-like quality, providing an image for 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 explicitly available. The lack of resources that definitely and directly linked pho-
Students’ Interpretation of Photographs

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, that is, the topic of this photograph.

Some students \( (n = 3) \) 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, identifying the lichens against the remaining background. However, they were not sure about what was the background 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 students 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. 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 \( (n = 9) \) recognized
the presence of an indexical reference that linked figure and text. The others \( (n = 3) \) 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 that 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 11) 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.

*Beyond Text, Caption, and Indexical Reference*

Visual information such as color, arrows, letters, geometric forms, 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 (Pozzer & Roth, 2003). 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 reconstruct the topic of the photograph
(orchid or bromeliad) was available in the photograph itself, existing in the inscription “orchid” on the bottom right. Taken in isolation, this information does not help the students to actually identify this specific object in the photograph, although it could still focus the readers’ interest towards something specific 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 identified 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 remained uncertain about which of the examples of epiphyte plants given by the text—orchid and bromeliad—was represented in the photograph. The word “orchid” inscribed into 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.

Role of Interview and Previous Knowledge and Experiences

“I though, ‘it’s a research, so there will be some trick in here.’”
(Adam, grade 11)

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 (Scholtz, 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 (grade 11) 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 same plant in the photograph.

During the debriefing session, 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.

Our study was designed such that we could investigate differences related to students’ previous knowledge when reading the photographs and texts. Thus, half of the students \((n = 6)\) had already had an advanced Ecology course in high school, and the other half \((n = 6)\) had not. We expected to be able to distinguish differences on students’ responses from those two distinct groups.
During our analysis, no differences on students’ responses were salient enough to justify being mentioned in this article. However, we were left with the overall “feeling” that the older and more schooled students from grade 11 did demonstrate some advantage in relation to the younger grade 8 and 9 students. This assumption is based on the fact that, overall, grade 11 students were faster in associating information provided on captions and main texts with the photographs. For instance, although most of the students, from both groups, encountered difficulties when first trying to interpret the photographs, grade 11 students more easily changed their interpretations after they had read the captions or texts accompanying the photographs. The older students also answered the questions posed by the interviewer in more “matter-of-factly,” whereas grades 8 and 9 students hesitated more when answering the same question, and demonstrated to have more doubts. We infer that older students, who have been attending school for longer, did develop some kind of literacy concerning reading textbooks with pictures, even if this literacy was not explicitly taught at school, as part of the curriculum.

**Discussion and Implications**

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. In this study we attempt to provide first answers to the questions, 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? through careful analysis of data collected from interviews with twelve students from different grade levels.

Our analysis revealed differences between single and multiple photographs. External comparison provided by the use of series of photographs allows the readers to easily distinguish differences and similarities between photographs. Thus, when interpreting the
photographs of camouflage, students could easily identify the differences on the plumage of the bird and on the environment. It was not so obvious to them, however, that the first and the third photographs of the series constituted examples of camouflage. Internal comparisons of each individual photograph became secondary to the work of interpretation. In these situations, other resources (caption, texts) were employed, when present, for highlighting important aspects to be observed, and guide the readers through their work of interpretation. Therefore, a series or a pair of photographs by itself is not enough to ensure the correct interpretation of the photographs. It is the interaction of all semiotic resources presented in the textbook, together with the photographs, that made possible to the reader to interpret and understand what he/she is reading. In the case of single photographs, even though the internal comparisons are immediately fostered, external resources still need to be associated to the photograph itself, during students’ working of reading these photographs.

The caption is a major aspect 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, as this association becomes subjective when explicit links (such as caption and indexical reference, for example) are missing. Therefore, it is important that every photograph have its own caption.

When the caption fails to help readers to unmistakably identify the “right detail” in the photograph, its existence is no longer essential to readers’ work of interpretation, insofar as they have to draw on resources other than the caption to identify the topic of the photograph. For instance, most students in our study successfully identified the orchid in the photograph by relying in characteristics inherent to the photograph itself, such as, for example, framing and focusing. These characteristics then became semiotic resources for the students to understand the photograph when the caption fails to help them to do so.

Our study revealed that main texts are 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 our analysis, it became clear that one of the major functions of photographs is to capture readers’ attention. The students interviewed noticed and commented on the photographs before referring to the texts. Although we were 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, we 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 lichen photograph, for example, we 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 readers to distinguish what they were seeing in the background.

On the other hand, our research shows that some photographs, as that 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. We 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.

Our analyses showed that students do pay attention to the indexical references to the figure when reading a textbook. The indexical reference to the lichens photograph provided a good example. When reading the text, the students immediately connected “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. The indexical reference is what allows the reader to connect photograph and text; therefore, it can be an essential resource to help readers to interpret photographs and texts in the context of learning a scientific concept.

Our study has the potential to inform teachers and textbook authors. Many of the concepts presented in science textbooks are abstract or unfamiliar 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 science 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. 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 helps readers in their work of interpretation and allows them to appropriately connect photographs and texts. For instance, students in this study demonstrated that they actually engage in a complex process of interpretation when reading texts with photographs, making use and connecting several different semiotic resources available on the textbook to understand what they are reading. Main texts, captions, indexical references, aspects of the photographic image, conventions of perspective, common sense, and previous knowledge and experiences, constitute some of the resources students’ used to achieve understanding.

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
lichen 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 enough information to the readers, so that they can in fact relate photograph and text. The concise, illustrative caption accompanying the photograph of the orchid, for example, was not enough to assist students in identifying the orchid in this photograph, which presented various other plants besides the orchid. Captions should also guide the readers through the photograph, helping them to distinguish relevant details. Thus, students did not distinguish between the actual lichens and the background on this photograph although the caption accompanying the photograph of the lichens explained that what could be seen in the photograph was the macroscopic aspect of lichens.

When students are reading textbooks, the way in which they interpret photographs greatly influences their understanding of the concept presented by the textbook. Thus, teachers should pay more attention to the complexities and subtleties of the processes involved in the interpretation of photographs when visual aids are used during their classes or on the textbooks they adopt. As it was made salient in this study, photographs can be confusing; captions and main texts may lack information necessary for students to connect photograph and text; students’ previous knowledge and experiences influence their reading of the text and figures. Therefore, teachers need to be aware that students not only need to develop subject matter literacy, but also a literacy concerning photographs to fully understand their textbooks.

References


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APPENDIX 1: Interview Guideline.

1- Introduction:
Informal conversation, when the interviewer introduces herself to the students, and briefly explains the research project. The interviewer also reminds students of some important aspects related to the interview (interview structure and general guidelines).

2- Interview Structure
2.1- Give the students the photograph of the orchid.

Questions:
What is this? (What is this photograph about? What are you looking at? What do you think is the topic of this photograph?)
Could you describe this photograph to me?

2.2- Give the students the caption associated with the photograph of the orchid.

Questions:
This is the caption that accompanies this photograph. Could you please read it aloud?
How about now: what is the topic of this photograph?
Could you please show me the epiphyte plant in the photograph?

2.3- Give the students the text associated with the figure.

Questions:
This is the main text that accompanies this figure. Could you please read the text aloud? I would like you to tell me everything you are doing, what you are looking at, what you are thinking...
What is this text about?
Now, what do you think is the topic of this photograph?
Could you please show me the epiphyte plant in the photograph?
What do you think could be the function of this photograph in the textbook? (Why?)
Do you think that reading the text, or the caption, or both, altered in any way your interpretation of the photograph? (How? Why?)
In your opinion, does the presence of this figure make any difference in the textbook, in this text? (How? Why?)

2.4- Give the students the photograph of the caterpillar (reproduction of the entire page, with photograph and text).

Questions:
This is a reproduction of a page of a textbook. I would like you to look at this page and tell me what you are doing: reading the texts, looking at the picture, what are you doing?
What do you think is the topic of this photograph?
Do you think there is a relation between photograph and text? (How could you relate them?)
What do you think is the function of this photograph here? (Why?)
Could you please tell me if you found any differences between this photograph and text and the previous one I showed you?

2.5- Give the students the photographs about camouflage.

Questions:
What is this? What are these photographs about?
Are these photographs in sequence? Are they about the same thing?
What is the topic of these photographs?

2.6- Give the students the caption associated with the multiple photographs about camouflage.

Questions:
This is the caption that accompanies these photographs. Could you please read it aloud?
Now, what is the topic of these photographs?
Do you think that the caption altered in any way your interpretation of these photographs?
Do you think these photographs are in sequence? (Explain)

2.7- Give the students the text associated with the multiple photographs about camouflage.

Questions:
This is the text associated with these photographs. Could you please tell me what you are doing? If you are reading the text, do it aloud, if you are looking at the photographs, tell me so...

What is the topic of the text? Do you think the text and the photographs are about the same thing?

What do you think is the function of these photographs in the text? (Explain).

2.8- Give the students the photograph of the lichens (reproduction of the entire page, with photograph and texts).

Questions:
This is a reproduction of a page of a textbook. I would like you to look at this page and tell me what you are doing: reading the texts, looking at the picture, what are you doing?

What do you think is the topic here?

Do you think there is a relation between texts (caption, main text) and figure? (Explain).

What do you think is the function of this figure in the text?

Could you please show me the lichen in the photograph? How do you know that is the lichen?

Is there a reference to the figure in the text?

Do you think that the caption/main text altered in any way your interpretation of the photograph? Did the photograph alter in any way you interpretation of the text?

Do you think the four photographs and texts I showed you are different somehow? (Explain).

3- Debriefing Section: students have the opportunity to talk about the interview.