Photographs in lectures: Gestures as meaning-making resources

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Abstract

Photographs are the most frequent inscriptions in high school biology textbooks. 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 when they appear in lectures. In this study, the use of photographs during lectures and lecture-type situations was analyzed with respect to the semiotic resources that speakers standing next to the projected photographs provided for understanding and learning from them. Our analysis identified eight types of gesture as semiotic resources that decreased the ambiguity inherent in photographs, and that have the potential to enhance the understanding of photographs and the scientific concepts embodied in them. We surmise that teachers can help their students learn to read and interpret photographs from lectures when they project them in such a way that it allows the use of gestures as additional meaning-making resources.
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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 usage in the social studies of science, visual representations in any medium (paper, computer monitor, projected image)

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are now referred to as "inscriptions" in the educational literature (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.

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 (Roth & Bowen, 1999; Roth, Bowen, & McGinn, 1999). Moreover, photographs and naturalistic drawings constitute the most prevalent type of inscription in high school biology textbooks (Pozzer & Roth, 2003; Roth et al., 1999b).

A previous study showed that a number of structural features of photographs in Brazilian high-school biology textbooks were shown to pose potential problems of interpretation (Pozzer & Roth, 2003). Because of the abundance of contextual detail, photographs lend themselves to multiple perceptions and interpretations by the reader/viewer. As a consequence, readers may not discern what exactly in the photograph is important to the scientific phenomenon to be taught. When photographs are used during a lecture, however, we may expect the lecturers to deploy semiotic resources that can be used by the audience in its efforts to make sense. For example, under certain circumstances, we expect lecturers to use gestures, pointing sticks, or lasers to point to a particular spot in the photograph; this pointing constitutes a *deictic* gesture (McNeill, 1992). Furthermore, lecturers can also use *iconic* gestures (McNeill, 1992), which get their name from the perceptual resemblance of gestures with the phenomena they depict. For example, following the shores of a lake on an aerial photograph or using two hands to illustrate the confluence of two creeks constitute iconic gestures. The purpose of the present study was to investigate the semiotic resources that lecturers make available to their audiences when they use photographs as illustrations in lectures, that is, situations in which one speaker talked about scientific issues while addressing a larger, mostly listening audience. We analyzed 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 assisted in making salient photographic detail pertain to the scientific issues at hand.

Our results indicate that gestures and body orientations constitute important resources for establishing coherence during lectures that allows audiences to appropriately connect photographs and speech. Therefore, this study is especially relevant for teachers and educational researchers interested in improving science classroom pedagogy and has implications for our understandings of how teachers coordinate multiple semiotic channels.

1. Background

When scientists interact with other scientists and when they teach and make use of inscriptions, they not only use words, but also they gesture, point, and create and move in real and imaginary spaces (Goodwin, 1995; Ochs, Gonzales, & Jacoby, 1996). This study is situated at the intersection of two domains of scholarly work in the context of scientific communication: (a) semiotics of photographs and associated text and (b) gesture studies.

1.1. Semiotics of photographs

Photographs can contain a great deal of undifferentiated information; they are full of what Myers (1990) calls "gratuitous detail" that allows multiple interpretations. This can be a source of confusion for students (Pozzer-Ardenghi & Roth, 2005). On the one hand, photographic detail provides a space that is continuous with the lived world, allowing viewers 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. Consider for instance the photograph in Fig. 1 and the text produced by the person talking about it. The use of deictic terms (which are inherently context sensitive) may cause difficulties in interpreting this figure. For instance, which mountains are "*these* mountains"? Where, in the photograph, is the "other side"? What exactly does the utterance "up here" refer to in this situation? In this example, an audience listening only to the narration would have to rely on peripheral clues for interpretation, taking into account not only the established

"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."

Fig. 1. Example of a photograph and a lecturer's utterances that explained what the audience is to see in it.

text but also the clues provided by the context to make sense (Brown & Duguid, 1992). In a speech situation the audience needs the resources of the gestures and body orientations that speakers use during their talk to make sense of the picture and the text (Roth & Lawless, 2002). This paper is centrally concerned with speakers' gestures and body orientations produced as semiotic resources for the audiences.

1.2. Talk, gesture and photographs

In a speech situation, such as a lecture, both 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 express developmentally more advanced concepts than the words do (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, 1999).

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, Chovil, Coates, & Roe, 1995). *Deictic* gestures are used in concrete or abstract pointing. These gestures are context dependent, that is, the utterances accompanying these gestures are "grounded" by means of a relation to the referent that is made salient by the deictic gesture. 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 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 (McNeill, 1992) 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.

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 aspects of 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).

2. Study design

To gain a better understanding of the relation between gestures and talk over and about photographs, we watched videotapes from a four-month seventh-grade ecology course, where, in several instances, a biologist-environmentalist assisted the two seventh-grade teachers in teaching the ecology of watersheds. In these situations, the speaker made use of photographs that were visually available to the audience and she used a variety of gestures. Both photographs and gestures were clearly visible from the perspective of the audience.

We began our analysis by jointly viewing the videotapes 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. In *Interaction Analysis*, even when we analyze unfamiliar data, we draw on our existing understanding of how the world works to make sense of these data. The analytic categories that emerge from an interaction-analytic session are not predetermined; rather, categories emerge as the analysts' understanding of the orderliness of the interaction evolves and becomes deeper. Interaction-analytic statements about general patterns are generated through empirical observations as an inductive process. The analysis meetings—which included ourselves (the authors) and other members of our research group, Chat@UVic[1]—were video-recorded, allowing us to establish key elements for the quality of interpretive inquiry. These quality criteria include (a) *progressive subjectivity*—knowledge about how our own understanding changed in and through the research—concerning the categories that we developed and (b) the construction of an *audit trail*—a historical record of our categories and changing understandings (Guba & Lincoln, 1989). In addition to the interaction analysis meetings, the authors also analyzed the data individually. All hypotheses and findings were presented, discussed, and critiqued during interaction analysis meetings with members of our research group, who served as *disinterested peers* (Guba & Lincoln, 1989).

During interaction analysis meetings, videotape replay was stopped whenever someone thought a significant event had occurred; that is, whenever someone wanted to comment on what was happening in the video, we stopped playing it to discuss that particular event, instance, or situation. For example, in one case somebody noticed the speaker's orientation when pointing to the photograph, which they thought was significant because generally, the speaker was oriented differently (i.e., towards the audience) and this led to a discussion about possible connections between body orientations and what the speaker was talking about (i.e., the photograph or something that could not be seen in the photograph). Ultimately, we noticed a pattern in body orientations, which we express in Table 1. The event was reviewed as often as necessary so that each tentative assertion could be fully explored by all

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[1] Chat@Uvic is an interdisciplinary research group at the University of Victoria, Victoria, BC, Canada. In this group, graduate students and post doctorate fellows work on research under the supervision of Dr. Wolff-Michael Roth. Please, refer to our website for further information about the group: www.educ.uvic.ca/chat.

Table 1
Functions of gestures in the presence of photographs and speech

Function	Gesture referent available in photo?	Type of gesture		Body orientation	N
		Deictic/iconic	Specific/generic		
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

participants. In the absence of a substantial body of prior research, we began our analyses without predetermined analytic categories, developing them together as our interaction analysis evolved; that is, we watched the videos repeatedly, discussed their contents, and generated hypotheses about what was happening, what the lecturer was doing, the relations between the lecturer, the photographs and the topic of discourse, etc. For example, our discussions about the speaker's body orientations happened before we had actually started paying attention to the speaker's gestures. Thus, we first hypothesized that the speaker would always turn towards the photograph every time she would talk about something directly connected to what was represented in the photograph. After further analysis, however, we noticed that the speaker turned towards the audience when talking about characteristics of the area represented in the photograph, thus disconfirming our initial hypothesis.

As our comments and assertions evolved, so did our analytic approach. First, we noticed that the most salient and important semiotic resource used in a lecture situation were the lecturer's gestures. Therefore, we proposed to classify the different gestures used to refer to the photographs during the lectures. We then selected episodes in which the lecturer was using projected photographs and gesturing over and about these photographs, and proceeded to a more careful analysis of these episodes. Ultimately, we selected a 15-minute lesson[2] to illustrate our final categories. During this particular lesson, the lecturer used several different photographs and she also performed various gestures, and both photographs and gestures were visually available to the audience. This configuration (i.e., visual availability of both photographs and gestures) was ideal to help us analyze the different functions of gestures as semiotic resources for interpreting photographs used for pedagogical purposes.

We engaged in a process of generating and refining each category by discussing all the examples of gestures provided and by developing criteria to distinguish each one of the categories. We changed our classification until we had identified a set of non-overlapping categories of gesture and body orientations that constituted meaning-making resources in talk over and about photographs. We subsequently counted all these gestures, and included them in one of the eight final categories we presented here.

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[2] An excerpt of this lesson together with video clips is available online at http://xml.talkbank.org.:8888/talkbank/file/talkbank/Class/Roth/.

3. Gestures and body orientations: semiotic resources for the interpretation of photographs

The study of gestures and body orientations as semiotic resources for understanding and learning from photographs is new to science education. We therefore begin by providing some principles of analysis that we developed as part of this work before moving to the description of the different functions that gestures and body orientations have as semiotic resources in the interpretation of photographs used during lectures.

3.1. 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 written or verbal text 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 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 and what the image means. 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 verbal text and are directed toward the photograph, providing anchors that integrate verbal text, photograph, and gestures into a total performance.

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

In a lecture situation, although the verbal text plays an important role in directing the audience towards the "intended details" of the photograph, there is potential ambiguity associated with the use of deictic terms. Because of this potential ambiguity, gestures and the body orientations function not only as the reference to the photograph, but also constitute the means by which verbal text and photograph are explicitly associated with each other. Through gestures, lecturers narrow the range of ways in which photographs can be viewed. 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 how to view the video recordings as evidence for the contention that Rodney King was not "beat up" but "intelligently kept under control." The police expert used selected still frames (photographs) of the video, and used gestures to point to specific aspects of these photographs to show "evidence" that Rodney King was in fact aggressively reacting to the police officers.

In our database, each specific instance of talk was directly associated with a correspondent gesture or body orientation, which, in turn, guided viewers through the photograph. In some cases we found that lecturers' utterances, taken in isolation, were imprecise, ambiguous or non-specific, but the use of gesture or bodily orientation narrowed the possibilities for multiple interpretations and otherwise clarified and enhanced communication.

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, we 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 provides resources for connecting verbal text and photograph, insofar as it provides cues to the audience about where to focus 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. In the examples we provide, when the lecturer turns towards the photograph, her body orientation can be read as though she were saying, "now look at the photograph." In contrast, when she turns sideways or fully to the audience, thus orienting her back to the photograph, the message becomes, "now pay attention to me and my gestures but not to the photograph."

3.2. Functions of gestures and body positions

The lecturers' gestures emerged as the most important semiotic resource that the audience could rely on to interpret the photographs in the course of a lecture. Describing each category of gestures allows us to analyze the interactions between photograph, text, and gestures that are associated with the work of interpreting and using photographs. Below, we 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.

In the particular lecture chosen, the biologist-environmentalist attempted to teach the concept of "watershed"; she drew on several photographs and maps mounted as slides that she projected against a screen covering the chalkboard. Throughout the presentation, the biologist-environmentalist stood next to and in front of the projection screen. We classified the different functions that gestures and body orientations have in relation to the interpretation of photographs. Our classification includes eight different functions of gestures and body orientations produced as semiotic resources for interpreting the photographs: (1) representing, (2) emphasizing, (3) highlighting, (4) pointing, (5) outlining, (6) adding, (7)

extending, and (8) positioning (Table 1). In this classification, we take into account the position of the lecturer when gesturing, 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 or phenomenon in the photograph, and the primary function of the gesture in relation to speech and photograph. The following aspects were considered to generate the different categories of gestures presented in this article:

- Gestures are deictic, iconic, or both: for our classification, "*pointing*" gestures are considered deictic, whereas gestures that resemble the shape of their referents are considered iconic gestures. However, an iconic gesture, at times, may also "*point*" to something particular in the photograph, in the sense that it may bring attention to a particular area of the photograph. In these latter cases, we considered the gestures deictic/iconic.
- The gestures are specific or generic: in our classification, specific gestures are all deictic gestures that are made with index finger, pointing to a particular object, using the photograph as a background or not. Alternatively, generic gestures are all those gestures, deictic, iconic, or both, that do not constitute a direct pointing, and which referent may not be clearly identified or circumscribed.
- The referent of the gesture is or is not available in the photograph: in other words, the gestures may use the photograph as a background or they are about something that cannot be seen in the photograph.
- The body orientation is towards the photograph or towards the audience: in our classification, the body orientation refers to the position of the lecturer at the exact time she was producing a particular gesture. That is, if the lecturer was turned towards the photograph when she was gesturing, this position is considered as a *"body orientation towards the photograph"*, and this is another aspect that distinguishes the different categories of gestures in this article. Therefore, if the lecturer is turned sideways, or completely to the audience, this body orientation is said to be *"towards the audience"*, and it is characteristic of some (but not others) of the categories of gestures we presented here.

The total number of gestures in the 15-min lecture was $N = 92$; in Table 1, we provide frequency data for this particular lecture.[3]

3.2.1. Representing

The gestures classified in this category include those 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

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[3] For the presentation of the data in this article, episodes were extracted from the 15-min lesson on watershed for the constitution of vignettes that exemplify our categories of gestures; these episodes were imported into iMovie (a program supplied with Macintosh computers), which allowed us 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. 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 film laid over the computer monitor, we produced drawings of the selected frames, tracing only the relevant features for the representation of each category of gestures and body orientations. The drawings were then scanned and inserted in this article.
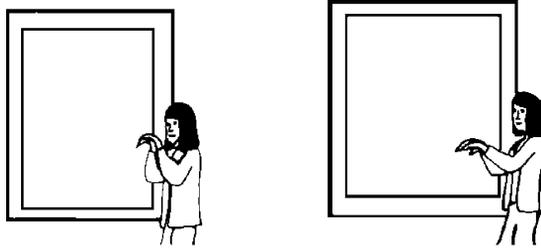
"And you go sort of through the Tsartlip Band Reserve, and you start to head down the hill a little bit..."

Fig. 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.

seen on the projected aerial photograph (Fig. 2). These gestures were iconic, resembling the shape or the movement of something real and familiar to the audience. They were also generic, both in form and referent. When using such gestures, the speaker was always (100% of the cases) oriented such that the speaker's regard fell somewhere between paralleling the projection screen to facing the audience. This type of gesture was the most frequent in the watershed lesson analyzed. In the entire presentation, 30 representing gestures were recorded.

Fig. 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.

These gestures, therefore, not only provided resources to focus attention, shifting the audience's attention from photograph/speaker to speaker alone at key junctures, but they also help to explain the topic of the discourse, insofar as they represent something not visually available in the photograph. That is, in the present situation, the audience could see in the photograph a bird's eye view of a 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 possible experiences of driving along this kind of road; That is, the gestures constituted an iconic, concretely embodied representation of driving along the road that was perceptually available to the audience only by means of the aerial photograph. The gestures opened up a third dimension in the photograph and connected it to the discourse and the real world the photograph partially represents.

3.2.2. Emphasizing

In this category, we 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. These gestures therefore also had a deictic function.
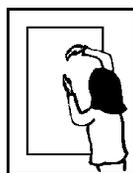
"Graham is coming up this way and Hagan is coming down this way."

Fig. 3. Example of an *emphasizing* gesture: The referent entity is available in the photograph, the gesture is generic and iconic/deictic, and the body orientation is toward the photograph.

When the speaker gestured in such cases, she was positioned towards the photograph and the gestured phenomenon was available in the photograph. Here, too, the speaker's orientation functioned as a frame orienting the audience to look at the relation between gesture and corresponding features in the photograph. In the lecture featured here, there were 20 emphasizing gestures produced during the presentation on the watershed concept.

In Fig. 3, for example, the gestures emphasized the confluence of two creeks (named "Graham" and "Hagan"), and how they come together at some point. The background for this gesture was 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 was 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 produced in the context of an orientation towards the audience signified what she verbally denoted as "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 Fig. 3, was classified as 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." Fig. 3 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 emphasized the aspect of a watershed as a drainage basin.

3.2.3. Highlighting

Highlighting gestures are deictic but generic, since they are usually circular or elliptical in shape without having clearly determined boundaries, and without a delimited referent. 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 present 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.
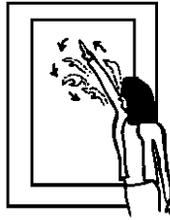
"And so up here, any idea [what this is]?"

Fig. 4. Example of *highlighting*. The gesture is iconic, pointing to something, but generic because the outline of the thing is not specifically identified. The orientation is toward the photograph.

In an aerial photograph, the identification of a mountain is made more difficult because the third dimension that would allow viewers to perceive heights is not available. What the speaker's gesture did, therefore, was to highlight that particular area in the photograph, providing the audience with a means to connect that area in the photograph with the word "mountain." Because there are no determined boundaries, however, it is harder to identify the object completely; the circular gesture (e.g., Fig. 4) then, simply directed the viewer's attention to the approximate area in the photograph. We counted 12 highlighting gestures during the mini-lesson on watersheds (Table 1).

We 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.

3.2.4. Pointing

Pointing gestures belong to the class of deictic gestures. During the lectures analyzed, the speaker 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 in the photograph. 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 to our classification. In the lesson about watersheds, there were eleven pointing gestures.

In Fig. 5, 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 Fig. 4. When the extensions of the denoted 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.

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
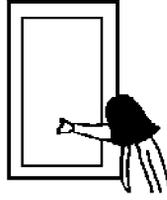
"And your school would be right here."

Fig. 5. Example of *pointing*. The gesture is specific and deictic and always with a body orientation towards the photograph.

delimited in the photograph. In this situation the possibilities of different interpretations of the photograph are narrowed such that only one interpretation is possible, 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 verbal text and photograph is immediate. However, when the entity to be referred to 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 may be more appropriate.

3.2.5. 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. The shape of this gesture depends on the visual availability of the object in the photograph, i.e., 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.

Fig. 6 exemplifies the outlining of a specific area in the photograph. Characteristically for this category of gestures, 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 from the audience's perspective. Because of the close spatial relation with the moving pointer (finger), the possibilities of mistaking the coastline and with it "Saanich Inlet" for
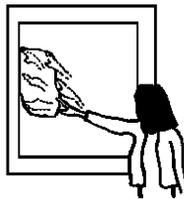
"So this would be Saanich Inlet over here."

Fig. 6. 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.

"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."

Fig. 7. Example of gestures that add something in the photograph. The gesture is specific and iconic/deictic, associated with a body orientation toward the inscription.

something else are greatly narrowed and the identification of the relevant details in the photograph is immediate.

3.2.6. Adding

Adding gestures were also used to outline entities, but, in this case, the object or 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 Fig. 7. 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 the biologist 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 semiotic resource for understanding photographs not achievable in a textbook.[4] The gestures can be understood as a form of concrete, public, and witnessable thinking.

3.2.7. Extending

These 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 had been taken from a greater distance,

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[4] One may argue that what the gesture is doing in this example (Fig. 7) could in fact be achieved in a textbook, through the codeployment of multiple photographs, or layered inscriptions, and explicit deictic text accompanying it. We do not deny that these latter arrangements could be made available in a textbook; however, the final result of what is achieved through the simultaneous, synchronous deployment of speech and gesture over and about the photograph in this example is not, in any way, possible in a textbook.
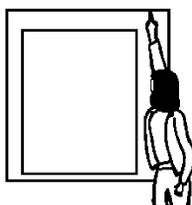
"Sidney is further up this way."

Fig. 8. Example of gestures that extends the photograph, pointing at something somewhere off the photograph and therefore not directly available but that would have been visible if the photograph had been larger; the body orientation is toward the photograph. The gesture is specific and deictic.

the entity would have been included (Fig. 8). The body orientation was always toward the photograph. In these cases, 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. In the watershed presentation, these gestures were observed three times.

As with the adding gestures, the audience is 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 in order to show to the audience something that is actually not visually available in it. It is almost as if the photograph was a different image; the lecturer points to objects that are just beyond the photograph's boundaries; occupying an imagined space, something like a representation on an extended screen. The audience is invited to follow the speaker through her gestures and speech to envision the aerial photograph as covering a little more area. Therefore, the lecturer can introduce additional elements that may assist the audience in understanding the concept or the location of the photograph with respect to the larger setting known to the audience.

3.2.8. Positioning

These types of gestures, generic and iconic, are strongly related to the body orientation, and constitute a form of extension into three-dimensional space. The speaker positioned herself against the photograph as if she were actually taking the shot at that exact moment, standing in the landscape depicted. The speaker therefore provides the audience, through her body orientation, a semiotic resource that may be used to interpret the photograph as if it were 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.

Fig. 9 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
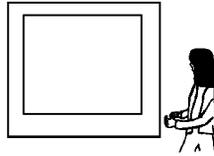
"So, we are standing on the southern boundary here."

Fig. 9. Example of *positioning*, a generic gesture of iconic type that, together with the body position, virtually extended the photograph into three-dimensional space.

related to it. The lecturer introduced the photograph to the audience as a depiction of the real world, making a direct connection 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 (Fig. 9) the lecturer was identifying 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 as 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.

4. 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 (Pozzer & Roth, 2003; Roth et al., 1999). The present study shows how hand gestures and body orientations provide additional semiotic resources that teachers and lecturers can make available for the interpretation 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. 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.

4.1. Gestures and photographs in science lessons

In this study, we identified eight categories of gestures that occurred during a 15-min lesson on watershed, at a grade seven class. These categories include representing, emphasizing, highlighting, pointing, outlining, adding, extending, and positioning, and they are distinguished by the function they have in relation to the photographs. All eight types

constitute important resources that are deployed in addition to verbal discourse for interpreting photographs, their contents, and their relevance to the theoretical concepts to be learned. These eight types of gesture categories constitute a range of semiotic resources not normally made available in textbooks. These findings have implications relative to our previous research in which we found that textbook captions and text do not enable students to adequately understand the meanings of photographs (Pozzer & Roth, 2003; Pozzer-Ardenghi & Roth, 2005). With present technology—photocopying, scanning—teachers could address this issue by actually projecting textbook images and, deploying relevant gestures and body positions, teach students how to select relevant detail to assist them in meaning-making processes. Further research could then investigate whether students' competencies in interpreting and learning from photographs used in textbooks increases when they are exposed to whole-class presentations and readings of photographs where the teacher makes effective use of gestures and body. Gestures and body orientations, by their very nature, can be "layered" onto the photographs without requiring the same types of work that the interpretation of layered inscriptions in textbooks, for example, require (Roth, Pozzer-Ardenghi, & Han, 2005). The gestures and body orientations that accompany speech and are directly related to the photographs allow the verbal text to be more specific and constrained in meaning than the written text. That is why, in some instances, we 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 similar explanation. Moreover, as exemplified throughout this article, gestures have the potential to transform the photographs, bridging the gap between two-dimensional representation of the world and the real world. Similarly, ambiguous references to the photographs through speech are clarified by the use of different gestures and body orientations, which constitute relevant semiotic resources to the interpretation of these photographs.

Lecturers and teachers who deploy gestures when using photographs in the classroom, are in fact implementing some of the recommendations educational psychologists have made with respect to the need to use multiple representations of the same concept (Snow, 1997); gestures are a means that make classroom teaching inherently adaptive to the representational needs of students.

In sum, we see that because of the role of gesture and bodily orientation in shaping audience readings of photographs used in lectures, those photographs become more valuable 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. Gestures and body orientations, thus, are crucial resources for establishing a coherence that allows audience to appropriately connect photograph and verbal text. Gestures, therefore, play an important role in science discourses, and should be more carefully investigated.

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