# Toward a Multimodal Approach of Science Teaching

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**Summary**
*Major studies in science education have analyzed teaching based on verbal or written mode. Some researches suggest a multimodal approach. Our research studies how a Greek teacher of Physics in a ninth grade classroom uses several modalities to teach the concept of potential energy. Based on the precepts of Interaction Analysis, we analyzed video until a common agreement about the criteria was established. The results show that teacher performed different aspects of potential energy by using scenery, scenic objects and iconic bodily movements. The concept of potential energy can be more effective if teachers take into consideration these modalities.*

**Key words**

*Physics teaching - Multimodal approach – Scenery - Scenic object - Iconic bodily movements*

## *Introduction*

For decades, major studies in science education have analyzed teaching only with some aspects of language. Indeed, verbal or written texts were the dominant mode used to analyze teachers' or students' activity. It is only recently that researchers have focused on a multimodal approach of science teaching and learning (e.g. Kress, Jewitt, Ogborn, & Tsatsarelis, 2001). Thus, novel perspectives put to the foreground all the semiotic resources perceiving them as "grammatical" genres of making sense, interplayed one another (e.g. Pozzer-Ardenghi & Roth, 2009). Speech, human body or spatial entities can be understood as vehicles of signs (i.e. semiotics resources) which support in different ways the construction of meanings. From this point of view, in any teaching event, scientific concepts are shaped by means of heterogeneous performances (Pozzer-Ardenghi & Roth, 2007) which are materialized in the classroom. The main idea behind such view is that semiotic resources situate teaching contexts which give knowledge shape (e.g., Kress, Jewitt, Ogborn, & Tsatsarelis, 2001) affecting the way of students' thinking.

## *Theoretical background*

In the context of adopting a multimodal approach with respect to science teaching (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001), it sounds promising to focus our research interest on verbal and visual (non verbal) modalities that teachers use in order to communicate scientific concepts. In this sense, we argue that the meaning is distributed among various semiotic resources (verbal and nonverbal), which are essentially raised by teacher's performance. On that basis, an attempt is made to highlight the complex ways in which modalities are rhetorically orchestrated in science classroom.

According to previous work about semiotic approach in science teaching (Givry & Roth, 2006; Pantidos, 2008), our study focuses on: (1) acoustic signs (linguistic and paralinguistic signs), (2) kinesic signs (gestural and mimic signs, proxemics), (3) spatial signs (scenery, scenic objects). The discussion on linguistic signs relies on Jakobson's (1966) view on six functions of language (emotive, referential, conative, metalingual, poetic, phatic), while paralinguistic signs refer to prosody. Gestural signs rest on the movements of the whole body (i.e. hands, head, torso, feet et al.). These signs include gestures, i.e. semiotic movement of hands and arms, and specifically such forms which are called gesticulation: iconic (descriptive) and deictic (pointing) gestures (Mc Neil, 1992). Mimic signs are connected with facial expressions, while proxemic with the displacements of the human body. Finally, spatial signs concern scenery, i.e. anything that grounds a setting which cannot be moved (e.g. a board with a drawing on it), and scenic objects which are considered as material, moving, entities which one can manipulate with ergotic gestures (e.g. experimental artifacts). Our research focuses on three relevant signs linked to the speech: the scenery, the scenic objects, and the movements of the whole human body.

## *Research questions*

This article emphasizes on how a physics teacher constructs his rhetorical style through various semiotic resources in a teaching about energy. More specifically our research needs to answer the following questions: Is this teaching of energy multimodal or not? Does teacher use only speech and written texts to teach the concepts about energy? What are the others modalities used by the teacher? The farther purpose is to examine how the teacher uses specific semiotic resources (i.e. different types of representational forms) in explanatory frameworks to perform various aspects of this physics concept. Although the above questions concern the topic of energy in general, we mention that, our analysis focused on several aspects of potential energy. Such a view does not essentially limit our research perspective for two reasons. First, in the specific lesson, the teacher takes advantage of the potential energy in order to exemplify 'how the concept of energy is conceptually organized' (e.g. conversion, store). Second, the kind of modes used in the episodes related to potential energy, are representative compared to the modes used in the entire teaching.

## *Research Design*

Concerning the methodological context of the study, we collected video data from a physics lesson about energy, which took place in a ninth grade classroom in Greece. The video analysis is based on three stages. First, we recognized various aspects of the concept of energy which occur in the lesson. Second, we detected the video clips in which teacher explains these specific aspects. Third, we identified the semiotic resources used by the teacher to perform each feature of the concept of energy.
Although, tools of semiotic analysis of the verbal mode were available to us (i.e. speech analysis context based on Jakobson's functions of language), we preferred to concentrate our analysis on the interplay between talk, scenery, scenic objects and body movements. We consider these elements as the protagonists of the 'story' of potential energy. Furthermore, following the precepts of Interaction Analysis proposed by Jordan & Henderson (1995), both authors established a common agreement about the interpretation of each video clip. This collective interpretation allows us to explicit the criteria used for the analysis of the video, and to put these criteria into our transcriptions.

## *Results*

Our point is to argue towards a multimodal approach for science teaching. In that way, our research shows that teacher uses more than speech and written texts to describe different aspects of the concept of potential energy. More specifically, our results illustrate how the teacher exposes the concept of potential energy by using (a) the scenery, (b) scenic objects and (c) iconic movements of body. We present our findings in terms of four assertions:

1. Teacher uses actively some elements of the scenery to express that potential energy is also converted into kinetic energy.
2. Teacher uses simultaneously elements of scenery and scenic object to illustrate that potential energy can be stored.
3. Teacher uses scenic objects to explain that various forms of energy can be converted into potential energy.
4. Teacher uses iconic bodily movements to describe situations from everyday life in which potential energy is stored or converted into another form.

***Teacher uses some elements of SCENERY to express a new aspect of the potential energy***

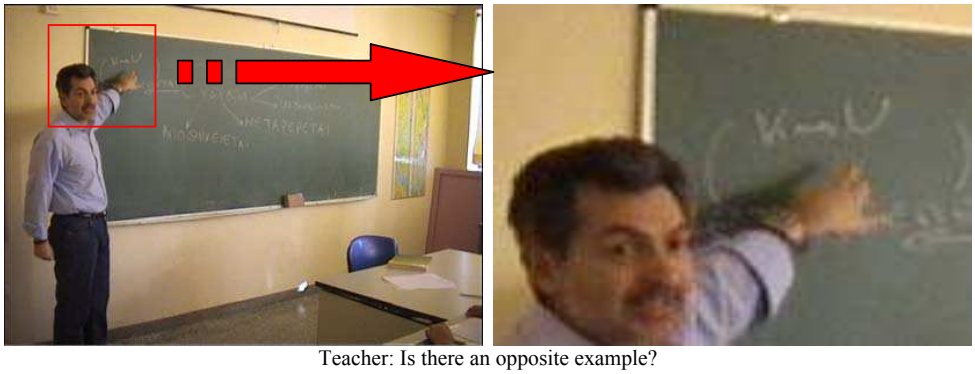
As far as spatiality concerns it should be mentioned that the blackboard is an important element of the scenery of the classroom. In our video, the lesson began when the teacher asked students to gradually construct a kind of conceptual map interconnecting the word "energy" with the verbs "produced", "consumed", "transported", "stored" and "converted" (figure 1). After that, he focused the discussion on the notion of "converted energy" by giving two examples (see figure 4 and 7 below). Sequentially, he wrote "K => U" above the verb "converted". When the teacher finished to complete the kind of conceptual map on the blackboard (figure 1), he asked students to give examples about kinetic energy converted into potential energy.

***Figure 1*** *Conceptual map of the concept of energy written on the blackboard*

The figure 1 shows the written text on the blackboard concerning some aspects of the concepts of energy. Traditionally, writing on the blackboard is perceived as a passive action which merely supports the explanations of the teacher. However, our data clearly demonstrates that scenery starts to be an active part of teacher's discourse. In this case, the deictic gestures (i.e. action of pointing) is the agent that joints teacher with blackboard and thus making him to use actively the written text on it.

Indeed, during the lesson, teacher points (deictic gesture) several times on specific words or relations on the blackboard. In episode 1, he uses the relation "K => U" written on the blackboard to express more than the idea of the kinetic energy is converted to potential energy. He uses simultaneously speech, deictic gestures and the text "K=>U" on the blackboard (scenery) to frame a question about the opposite relation (U=>K), i.e. potential energy is converted to kinetic energy (figure 2).

- Episode 1:



Teacher: Is there an opposite example?

***Figure 2*** *Teacher expresses another aspect of the potential energy through speech, deictic gestures and the written text on the blackboard (scenery)*

Figure 2 shows how teacher expresses a new link between kinetic and potential energy through: (a) his speech ("is there an opposite example?"), (b) his deictic gesture (his finger is pointing on the blackboard) and (c) the written relation "K=>U" (scenery). We interpret the figure 2 as teacher asks students to give an example of the conversion of potential energy into kinetic one.

This example shows that teacher's deictic gesture allows him to express more than what is contained separately in his speech and the written relation. That happens, because the meaning is conveyed simultaneously by three modalities. Actually, this episode illustrates how teacher's deictic gestures function as a bridge between speech and written text constructing a compact ensemble of meaning about a new aspect of potential energy (i.e. U=>K).

***Teacher uses SCENIC OBJECT and SCENERY to express the concept of potential energy***

This part shows how teacher uses a chalk (scenic object) and the blackboard (scenery) to convince students that an object (i.e. the chalk) can store potential energy. In this example, we argue that teacher expresses some aspect of the concept of potential energy by using scenic object and scenery in a specific way.
Just before the episode 2, the teacher discussed with students on examples of stored energy. He made the following questions: "What potential energy is?" and, "Is it a form of stored energy?" The majority of students answered that potential energy is not a form of stored energy. Then, teacher by means of the simultaneous use of (a) a scenic object, (i.e. a chalk), and (b) the scenery, (i.e. the blackboard) attempted to demonstrate to students that an object can really store potential energy.

- Episode 2 :

Teacher puts the chalk on the upper side of the blackboard and explains that the chalk has stored potential energy. He demonstrates this point by hitting the blackboard with his fist, which is causing the fall of the chalk (figure 3).

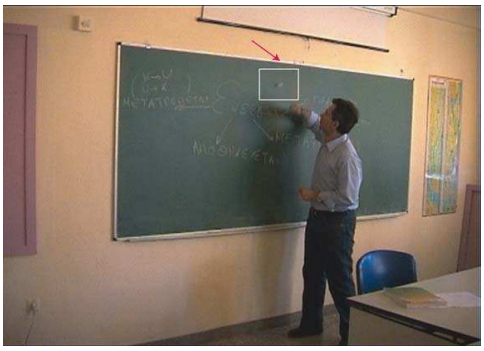


***Figure 3*** *Teacher has put a chalk on the upper side of the blackboard. The chalk falls when he hits slightly on the blackboard*

The fact that the chalk is falling down provides evidence that it had stored potential energy. More generally, teacher explained to students that objects contain energy (e.g., potential energy) when they are able to produce an action, or a change in their state or in their position. Teacher's performance underscored this change in terms of the conversion to another form (i.e., from potential to kinetic energy).

Teacher performed his demonstration by using simultaneously scenic object and scenery through ergotic gestures (i.e. movements of hands and arms to handle objects). In this example, teacher uses ergotic gestures to put the chalk on the upper side of the blackboard and to hit the blackboard. These gestures have a central role in teacher's performance. They show that he uses more than speech to explain that potential energy can be stored.

***Teacher uses SCENIC OBJECTS to express the concept of potential energy***

In this part, we show how teacher explains two aspects of the potential energy by handling some scenic objects. Indeed, episode 3 presents how the teacher chooses to toss a book in order to exemplify the conversion from kinetic to potential energy, and episode 4 shows how he lifts up a chair to illustrate how chemical energy is converted into potential energy.

- Episode 3:

A student spoke about the conversion from kinetic to potential energy. Teacher illustrates this issue by tossing up a book (figure 4).

***Figure 4*** *Teacher is tossing a book to exemplify the conversion from kinetic to potential energy*

- Episode 4 :

Providing another example teacher talked with students about the conversion from chemical to potential energy. He illustrated this specific relation between the two forms of energy by lifting a chair up (figure 5).

***Figure 5*** *Teacher lifts up a chair to illustrate how chemical energy is converted into potential energy*

Besides, the action to elevate a chair also brings out some other aspects of the concept of energy, as for instance is the conversion from kinetic to potential energy, or the fact that an object can store energy. However, from a multimodal approach, the figure 5 describes in which way teacher is putting the chair up. Namely, he puts the chair up, while, at the same time he places his second hand on his arm. We consider that teacher refers to his body by doing this second gesture (glossed as a kind of deictic gesture). This second gesture underlines that the body of the teacher (specifically his arm) contained chemical energy, whereas the other ergotic gesture supports the idea about the potential energy. The general picture conveys the meaning of the chemical energy is converted into potential energy.

Both examples demonstrate how teacher expresses that various forms of energy can be converted into potential energy by using different scenic objects. In these examples the teacher's body movements, especially the ergotic gestures, are essential to understand his explanation.

***Teacher uses ICONIC BODILY MOVEMENTS to express the concept of potential energy***

In the previous episodes, we showed how teacher used real material (as scenic objects and scenery) to express some aspects of the potential energy. In this part, we pay attention on how the teacher explains some aspects of the potential energy when scenic objects and scenery are absent from the classroom's setting. We present two examples in which teacher illustrates aspects of the potential energy by means of iconic bodily movements. Representing a bowman stretching a bow (figure 6) and an oscillated swing (figure 7). Both examples illustrate that teacher uses more than speech to teach concepts about potential energy.

Iconic bodily movements depict objects or events through human body movements. Such visualizations are not just mere representations of human actions or objects activities. They obtain a dynamic role in the teaching process since they gradually construct aspects of physics knowledge.

- Episode 5 :

Students and teacher discussed about how the potential energy can be stored. Teacher performed this idea with iconic bodily movement of "stretching the string of a bow" (figure 6).

***Figure 6*** *Teacher performs iconic bodily movement to stretch the string of a bow in order to illustrate how potential energy is stored*

Episode 5 shows how the teacher adopts with his body the posture of a bowman and does simultaneously the iconic gesture to stretch the string of a bow. This somatic figure on the stage illustrates the concept of stored energy by iconically reflecting to the property of a bow.

- Episode 6 :

In the same way, teacher performed the conversion from kinetic to potential energy by describing the movement of an imaginary swing (figure 7).

"I have…a swing….I am pushing it…

(a)

the swing is going up…"

(b)

***Figure 7*** *Teacher illustrates with iconic gestures (bodily movements) how kinetic energy is converted to potential energy.*

In figure 7 (a) teacher pushes an imaginary swing using simultaneously the utterance: “I have a swing... I'am pushing it” and an iconic movement of pushing. In Figure 7(b), teacher’s utterance: "the swing is going up" defines him as a moving swing. Additionally, his bodily functionality represents the features of a moving swing. By performing multimodal explanation, the teacher attempts to describe a situation in which the kinetic energy is converted into potential energy. However, the trajectory of the “swing” needs to go up to illustrate the conversion from kinetic to potential energy. But, as we can see in figure 7 (b), the horizontal body movement has a more important role than the hands’ movement of going up. In that way, students could understand that the conversion from kinetic into potential energy happens when a swing is moving horizontally. This kind of misunderstanding can appear when students focus on the movement of teacher’s body instead of his gestures. Maybe teacher could prepare some additional iconic gestures about potential energy to avoid the ambiguity with others gestures or body movements.

## *Discussion*

Our results indicate that teacher takes advantage of more than speech and written text to perform some aspects of the concept of potential energy. Indeed, he actively used (a) the scenery (e.g. blackboard) in relation with deictic gestures, (b) scenic objects (e.g. chalk, book and chair) framed by ergotic gestures and (c) iconic gestures or body movements to refer to imaginary objects or events (e.g. swing or bow). The implications for science teaching are important, because the modalities used to describe aspects of energy could be directly available to other teachers for adapting them into their instructions. Thus, teachers, by taking advantage from this, are getting aware that anything is communicated cannot be confined in the verbal mode.

In general, it is our strong belief that a meaningful ensemble of semiotic resources such as gestures, displacements of teacher’s body, material objects, drawings and verbal co-text can be significant in introducing a new concept, or approaching “hidden” aspects of it. However, teachers generally prepare their patterns of explanations and the written texts before the lesson. That is why, we propose that teachers have to design each lesson taking into consideration of a multimodal approach, i.e. they have to (a) select around scenery, scenic objects and iconic gestures, those which are the most relevant to explain some aspects of the concept, and (b) try also to minimize the ambiguous gestures.

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