

Towards applied semiotics: An analysis of iconic gestural signs regarding physics teaching in the light of theatre semiotics*

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Abstract

This study seeks to profit from theatre semiotics in order to investigate how semiosis can be implemented in the teaching of physics. It is based on the notion that in most human meaning-making situations, semiotic resources such as acoustic, spatial, and kinesic sign-systems evolve so as to complement and supplement one another. Traditionally, this particular view derives from theatre, where the signs conveyed from the theatrical performance effectively contribute to the construction of meaning; in terms of expression of dramatic signs, the actor is trained to compose modes in order to shape them on the stage. This article provides a classification of iconic gestural signs (i.e., movements of the entire body as opposed to gestures as mere movements of the hands), concerning physics teaching within a theatrical kinesic context. Through certain examples, corporeal functions and types are identified according to their cooperation with spatial semiotic resources, their temporal definition of actions, their proximity to the form of the referent, their relation to the content of the referent, and their collaboration with utterances. Furthermore, it is suggested that the practical implementation of theatre semiotics in physics education could help create a common, distinct and 'tangible' language among researchers, educators, and students.

Keywords: iconic; semiotics; gestural signs; teaching; physics; theatre.

1. Introduction

Although in the past there has been the tendency to perceive communication as a language-based system, the stance is now changing. Particularly in the field of cognitive sciences, many researchers support the idea that what is communicated is semantically charged through the semiotic

resources used to convey it (e.g., Scherer 1980; Sanders 1987; Leeds-Hurwitz 1989; Bavelas et al. 1997; Bavelas and Chovil 2000). This means that human mental representations also depend on the vehicle conveying the content of the message. Hence, communication itself consists of a multi-channel process in which acoustic and visual modes interact in a unique way. This functional interdependence between different modes clearly demonstrates that visible and audible acts are all signifiers of the same perceptual event. Narrowing that down to a teaching-apprenticeship context, both school and theatre are areas where, in order for meanings to be illustrated, multimodal texts are naturally activated in human interaction. Particularly in theatre, the written text retains its literary value while the theatrical performance itself constitutes the field where acoustic and visual codes are interwoven. Actually, the theatrical performance is the instantiation of drama. Numerous *signs* of the stage image are based on the performance and — either explicitly or implicitly — help shape the meanings which make up the plot (e.g., Elam 1980; Pfister 1988 [1977]). Thus, it seems worthwhile to investigate teaching as a sign-based process of communication that can be developed and improved through theatre semiotics.

Furthermore, the authors believe that the traditional perspective on science education does not make sufficient use of the experiential aspects of teaching and avoids facing them as signs that can affect or reshape interpretation. Research in science education does not usually propose ways in which principles and organizational rules derived from pedagogic models *can be materialized* in the science classroom into specific sign-vehicles with a view to conveying meanings (i.e., a ‘text’ may be spoken, written, depicted in an image or represented by the human body and all of these ways construct a communicative ensemble).

This study follows the notion of *applied semiotics*, which has been recently developed, and which promotes the idea of implementing semiotics in fields such as education or — as is the case at hand — instruction (e.g., Anward 1999; Seel 1999; Danesi 2003; Dimopoulos et al. 2003). In the context of science teaching, several studies have been conducted that interrelate the generation of semiosis with instruction and learning (e.g., Jewitt et al. 2000; Jewitt et al. 2001; Roth and Welzel 2001).

Specifically, this paper uses theatre semiotics as its background and seeks to lay ground for analyzing *iconic gestural signs* (i.e., gestural signs concerning movements of the entire body as opposed to gestures concerning movement of the hands), as they occur or as could be implemented in teaching physics. According to Charles S. Peirce, who introduced the field of contemporary semiotics, gestural signs — as any sign — can be *iconic*, *deictic*, or *symbolic*. Without going into further detail, an iconic sign

realizes its meaning through concrete resemblance or indirect relevance to its referent; a deictic sign just refers to it in the sense of pointing, while a symbolic one constructs a conventional, unclarified relationship with the referent (Elam 1980: 21–22).

The methodological perspective of this research is based mainly on (self-) observation patterns, with data derived from a physics teacher's professional daily activity. To be more precise, in this study, a physics teacher investigates how iconic gestural signs can be visualized (referring to their forms and functionality) through theatre semiotics in the classroom. Other physics teachers are also involved in the study offering additional data in terms of kinesic 'texts.' The entire project lasted three years and — apart from iconic gestural signs — also dealt with acoustic signs (i.e., the functions of speech, sounds, etc.), the remaining kinesic signs (such as mimic and proxemic signs) and, eventually, spatial signs (e.g., spatial functionality of decoration, scenic objects, lighting, etc.). Although the proposed typology of iconic gestural signs has been defined here based on the teachers' activity in particular, it is however suggested that this approach may provide a general expressive pattern that in future attempts could be used when dealing with the student's role in the learning procedure.

Concerning the structure of the paper and in order for the reader to acquire the appropriate background, some previous research on gestures and gestural semiosis is first reviewed; some cases concerning the field of science education are also discussed. The theory of theatre semiotics is then introduced, including the views of some theoreticians regarding the corporeal function in theatre. Finally, the findings of the study are presented, including a typology of iconic gestural signs in physics teaching.

2. Previous research on classification of gestures and gestural signs

Over the past four decades at least, several researchers have focused on the study of body language (e.g., Birdwhistell 1971; Mehrabian 1971; Pease 1981). That is, aside from verbal communication, humans can be equally effective when using movements of their body, posture, face, vocal features, etc. (Argyle and Trower 1980: 4). A number of studies involving gestures have organized them into distinct classes depending on the criteria adopted each time. With respect to gestures as sign-vehicles conveying meaning, many researchers have stressed their capability to describe or represent the forms or particular features of concrete events (Kendon 1987). Narrowing this down, Clark and Gerrig (1990) note that gestures may signify states of affairs, processes, and objects, while other

authors distinguish a class of gestures that can even stand as spoken utterances in their own right (e.g., Efron 1972; Wiener et al. 1972; Streeck and Knapp 1992). Regarding the functionality of gestures, which is what matters here, Efron (1972: 125) distinguishes those representing visual objects, which he calls *iconographic*, from those performing actions, which he calls *kinetographic*.

Apart from that, Efron (1972: 159) also claimed that *some gestures can just co-occur with speech*, providing rhythm to the utterances, while their frequency of emergence depends on the socioeconomic level of the interlocutors. In accordance with this, Ekman and Friesen (1972) assert that, for this type of gesture, the more enthusiastic the speaker is, the more possible it is that the gestures be concurrent; this occurs when the speaker has a crucial role in the discourse. Moreover, Martinec (2004) argues that, in human interactions, the speaker's enthusiasm, and affect can often suppress his/her control on the gestures used, but as time goes by these gestures become more spontaneous and better related to the meanings conveyed.

Pozzer-Ardenghi and Roth (2005) take a closer look at gestures and orientations of the body when they refer to inscriptions contained in photographs used during lectures. The two researchers refer to the function of gestures as *representing* when their referent does not directly appear in the photograph, as *emphasizing* when they emphasize on particular features of it, and as *highlighting* when they are used in cyclical or elliptical forms, quite different from the forms of the inscriptions, in order to bring out the entire content. Furthermore, an activity of a gesture is characterized as *pointing* when it shows (points) to a concrete element or to the entire image, as *outlining*, when it just reveals the shape of a contained entity, as *adding*, when it adds something (a new inscription), as *extending*, when the additional component is located outside the limits of the photograph, and eventually as *positioning*, when — combined with the orientation of the speaker's body — it extends the entire content to three dimensional space. Pozzer-Ardenghi and Roth argue that the main idea behind these functions is that gestures can act as filters that — when 'placed' onto a photograph — offer a deeper insight into the subject matter.

At a semantic level, some views have been developed on the basis that gestures are not connected with the construction of meanings, supporting the idea that they function more as signals in order for a lexical search to be accelerated, or in a dialogue in order to signify acts such as 'don't interrupt me,' etc. (Butterworth and Hadar 1989). On the contrary, some researchers integrate gestures with speech and thus regard them as (conceptual) components of the same meaning (e.g., Kendon 1987; McNeil 1985, 1992). McNeil suggests that gestures capture the instantial aspect

of thought that is built in instantial interactions. He also postulates that they cannot be extracted into structural components in order for a gestural syntax to be composed (e.g., Roth and Lawless 2002; Martinec 2004). On the other hand, approaches conducted based on a systematic perspective suggest that gestures can be deconstructed into their substance, which has a deep internal relation with cognitive processes (e.g., Halliday 1994; O'Toole 1994; Martinec 2004). Hence, going down that track, it seems reasonable to assume that *gestures constitute a system with particular principles, functions, and structures*, equivalent in a way to that of language. Thus, there are many researchers who support the idea that human non-verbal acts carry a mixed syntax capable of communicating any element of a clause (e.g., Bavelas and Chovil 2000).

Concerning the teaching of physics, very few studies have been conducted that approach kinesic means as interventional vehicles transmitting meanings, although Lemke (1999) did note that gestures can convey some aspects of natural phenomena more appropriately than language can.

Roth and Lawless (2002) report that when students make contact with scientific entities in laboratory conditions, the use of gestures in this initial 'reconnaissance' stage is dominant, preceding or even fully substituting speech. Students resort to gestures because of the temporary insufficiency of language to convey aspects of their 'new' environment, while their gesticulations still retain a satisfactory degree of accuracy with respect to the scientific content. Based on the empirical data collected from the students' interaction with *Interactive Physics* software, the two researchers note that students make gradual use of gestures to disengage themselves from such linguistic weaknesses, thus contributing to the establishment of a 'scientific language.' Finally, Roth and Lawless emphasize the *gestures' capability to describe even complex meanings*, either in an early non-lexical stage or in speech-related acts, in terms of their conceptual connection with the concurrent utterances.

Kress et al. (2001) concentrate on the multimodality of communication in the science classroom. They subdivide kinesic acts into *gestures, changes in posture, displacements of the body, and actions on objects*. What is particularly interesting is that, according to the degree of abstraction, the authors suggest that actions on objects may be considered as falling into one of the following classes: action on actual object (*manipulation*), action on represented objects (*model*) and thought as action (*thought experiment — pantomime*). The researchers describe kinesic acts as modes of representation particularly for invisible scientific entities and also claim that the meaning-making is closely connected to the sign-making process. Along these lines, Pantidos and Patapis (2005) designed some kinesthetically-

oriented tasks in which 17-year-old students experienced transverse waves through their bodies. Students stood up and impersonated molecules, thus generating waveforms as well as snapshots and creating perceptual kinesic data regarding concepts such as the period of the molecule, the wave period, and wave length. Actually, whether based on a cognitive or a socio-cognitive approach, these kinds of activities can lead students to sign-making processes in which the signifier and the signified are concretely interwoven within the event. This means that each student must explain — with more or less intervention on the part of the teacher — his or her own actions and thoughts (e.g., Ogborn et al. 1996; Roth and Welzel 2001; Ravanis et al. 2004).

3. Some aspects of theatrical corporeal context

During the twentieth century in Europe, many theoreticians of theatre as well as some great stage directors were skeptical towards the already established kinesic forms concerning the performer's body language. Eventually, after reconsidering this deficiency, they focused on oriental theatrical traditions, adopting the stance found in Asian theatre, namely that the performer's corporeal expressiveness is more significant than speech. For example, the *Kathakali* traditional Indian dance-theatre (Kathakali, which lays stress on dance, originated in the Indian state of Kerala during the seventeenth century) contains roughly 800 kinesic units (mudras): 64 movements of the knee, 9 movements of the head, 11 kinds of gaze, etc. (Ikegami 1971; Brandon 1993: 73). This disclosed power of kinesic signs no doubt derives from their essential depth. For example, Antonin Artaud (1896–1948), the French playwright, poet, actor, and surrealist drama director, emphasized kinesic signs and referred to them as a complete language of *ideographic* value (Elam 1980: 69).

Konstantin Stanislavski (1863–1938), the Russian theoretician, theatre director, and acting innovator of realist theatre, stressed, in the context of training, the actors' responsibility to observe and analyze the everyday impulses of their physical actions, as well as the behavior of others, even if that meant imposing specialized requirements on their daily kinesic praxis (Barba 1995: 28). He integrated physical actions into the rehearsals because of his belief that actors did not exhibit their corporeal performance to a satisfactory degree regarding the specific personage constructed (Law and Gordon 1996: 5). In fact, his Method of Physical Action was little related to the overall behavior of the body; rather, it addressed the specific character and the construction of the role was actualized in the theatrical performance (Barba and Savarese 1991: 152).

Vsevolod Meyerhold (1874–1939), the Russian theoretician and theatre director who was mainly concerned with research of the actor's bodily plasticity, had some experience with the physical laws that govern the human body when a performer is training (Barba 1995: 20). He used the term *biomechanics* to establish sets of movements that, according to him, were forceful or 'theatrical.' Actually, biomechanics consisted of a kineshetic training system in which, contrary to Stanislavski, the actor constructed corporeal forms (figures) at a level that was neutral to the role (Law and Gordon 1996: 5). Biomechanics was based on exercises derived from areas such as the circus, music halls, boxing, gymnastics, military discipline, the Chinese theatre, and Kabuki theatre (i.e., a traditional form of Japanese theatre¹ that began around 1600 when a woman named Okuni introduced a new dance called Kabuki) (Brandon 1993: 147). Thus, actors were focused on activities such as:

... An actor leaps down, throws a stone, shoots an arrow, slaps another actor in the face, stabs with a dagger, leaps onto the partner's back, the partner begins to run, he/she leaps down again, throws another partner on to the shoulder ... (Barba and Savarese 1991: 157)

Meyerhold refers to bodily plasticity as a concept strongly related to the mobility of the body as well as its immobility. His work is oriented to the functional specialization of muscular tensions occurring in physical actions, connecting them with specific feelings and states-of-affair (Law and Gordon 1996: 39).

Jerzy Grotowski (1933–1999) was a Polish theatre director supporting a kind of ritual theatre. He extended Stanislavski's work and advocated the significance of self-observation in realistic acts as well as its implementation in constructing a semiotic code of kinesic activity (Richards 1995: 101, 104). Grotowski's main concern was the approach of the 'living stream of impulses' (cf. Richards 1995: 104) rather than the revitalization of daily life. At the same time, in his Polish Theatre Laboratory, he developed a reinvention of Meyerhold's Biomechanics (Law and Gordon 1996: 6, 7).

The behavior of the performer's body is codified by the kinesic signs that, according to theatre semiotics, can be subdivided into *mimic* signs, corresponding to facial movements expressing emotions, *proxemic* signs, concerning displacements of the body, and *gestural* signs, dealing with all the other movements of the body such as those of the hands and feet, repositioning of the spinal column, head movements etc. (e.g., Kowzan 1975; Veltruský 1976; Fischer-Lichte 1992 [1983]). Defined in terms of the typology described above, kinesic signs in theatre constitute an

Table 1. *Aspects of iconic gestural signs concerning physics teaching*

Iconic gestural signs	
Criteria of classification	Functions (and types)
<i>Cooperation with spatial semiotic resources</i>	Highlighted by the props Inscribed in the decoration
<i>Temporal definition of actions/activities</i>	'Leading actor' 'Character actor'
<i>Proximity to the form of the referent</i>	Imitation Equivalence Metaphor
<i>Relation to the content of the referent</i>	Human action or activity Object or entity (and its activity)
<i>Collaboration with utterances</i>	Complementation or supplementation Speaker's alienation from the gestural 'text'

autonomous system of semiotic resources that are interlinked, contributing to the corpus of the theatrical performance.

4. Theatre semiotics in physics teaching: The case of iconic gestural signs

Concerning physics teaching, significant classifications of iconic gestural signs are distinguished by taking into consideration their *cooperation with spatial semiotic resources*, *temporal definition of actions/activities*, *proximity to the form of the referent*, *relation to the content of the referent* and *collaboration with utterances*. (Table 1 summarizes the results of the analysis).

4.1. *Cooperation with spatial semiotic resources*

There is continuous interest as to how iconic gestural signs can cooperate with other semiotic resources, especially spatial ones. In theatrical code systems, spatial signs concern the space defined by the stage and what is specified by the building or the surroundings when the theatrical performance takes place in an open area (Fischer-Lichte 1992 [1983]: 96; Quinn 1995: 101). As far as the spatiality of the stage is concerned, it comprises the decoration, the props (scenic objects), the lighting, and even the spatial coexistence of the bodies. Veltruský (1964 [1940]) describes drama as a continuum in which actor and object can overlap, also considering that any kind of sign-vehicle or objects can indicate a specific action. Furthermore, Pavis (1985) introduces a device (questionnaire) for analyzing

theatrical performance and notes the vital relationship between spatial forms and gestural signs, explaining that corporeal expressions can contribute to scenographic constructions.

Making use of the fruitful cooperation between spatial modalities and iconic gestural signs, we first investigate how the props (i.e., the objects carried or displaced during the theatrical performance) can serve as markers that highlight kinesic semiosis, and then look at how the corporeal modes of dramatic presentation can be inscribed as essential elements of the decoration.

4.1.1. *Highlighted by the props.* For example, in traditional Japanese theatre (e.g., Kabuki theatre) and dance, props are used in conjunction with gestures in order to render the position of the hands unambiguous. Hence, Kabuki actors hold a fan or handkerchief in order to elucidate the constructed kinesic semiosis and enrich its meaning (Barba and Savarese 1991: 140). In the instance shown in figure 22, the physics teacher could — to some extent — hold a book, a pencil, or a piece of cardboard in his moving hand, just to make students focus on the semiotic resource. Thus, in the transverse wave propagation act performed in the author's classroom using the students' bodies, each student held a square piece of red cardboard in his oscillating hands, indicating the points of equilibrium, and the crests and troughs of the waves (cf., Pantidos and Patapis 2005).

4.1.2. *Inscribed in the decoration.* Decoration in itself subordinates spatiality and signifies — either realistically, conventionally or even through its absence — the dramatic space (Arnott 1962: 91–93). Regardless of its constancy or its variability with scenes, the scenery defines the location of the dramatic occurrence and is attuned to the performer's pre-identified movements (Quinn 1995: 103). Hence, the actor can walk, dance, and run, being corporeally inherent to the spatial content of the drama (Aston and Savona 1991: 112).

In figures 1 and 2, the teacher directly cooperates with the scenery by inscribing himself into the surface of the board, reshaping the two-dimensional inscriptions (spring-ball system and closed circuit) into powerful three-dimensional constructions. In figure 1, the content of the speech contributes so as for the teacher to act as the subject generating the motion (i.e., 'I pull the ball'). Conversely, in figure 2, a hybrid figure is established with a view to retaining the teacher's objectification along with his subjectification (i.e., 'I am a voltmeter').



Figure 1. *The teacher 'pulls' the ball that is tied to the spring*

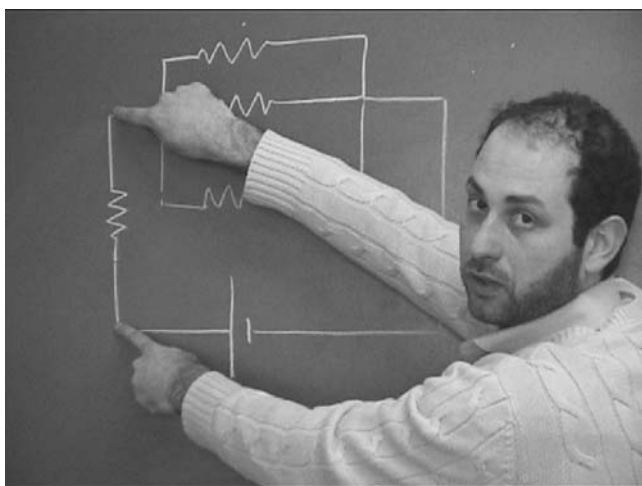


Figure 2. *The teacher pretends to be voltmeter and 'measures' the potential difference at the resistor*

Particularly in the composition shown in figure 2, the most salient visual feature is the teacher's face. It is interesting that since it represents the screen of a voltmeter, it provides the students with the opportunity to read the values of the potential difference (i.e., the values can be signified by means of deliberate movements of the teacher's eyes).

4.2. *Temporal definition of actions/activities*

In Asian theatrical tradition, the actor's posture establishes the character and pantomime constitutes a basic element of the theatrical performance (e.g., Wichmann 1991; Brandon 1993). In oriental theatre, as opposed to occidental, kinesic modes are interwoven with the structure of events, demanding from the spectator explicit corporeal decodification in order to reveal their meanings (Barba 1995: 16–20).

Thus, in accordance to oriental tradition, gestural signs may be viewed as structures that can either stand as 'leading actors' or maintain a more neutral role and contribute as 'character actors' in the weaving of the theatrical performance. Consequently, in physics teaching, iconic kinesic semiosis has a 'leading role' when it constitutes the activities' prominent feature. For instance, the corporeal reenactment of the oscillation of a molecule (cf., figures 9, 22, and 25) takes up a significant amount of the instruction time, not only providing a general idea about the natural phenomenon, but also elaborating on its particular features and mechanisms. This crucial role of these kinesic representations provides students with the opportunity to explore and investigate various aspects of physics such as the transformation of energy, the trajectory of vectors (velocity, acceleration, force) or — in terms of visualization — it gives them the chance to explain why the kinetic energy is zero in the position of total amplitude and so on.

On the other hand, iconic gestural signs as 'character actors' are reduced to a lesser role in terms of interventions. They usually offer some kind of conceptual disengagement in cases of misunderstanding (cf., Roth and Lawless 2002) or act as kinesic interpolations emphasizing instruction at a particular instant. In figures 3 and 4, while the students are working on a concrete task, the teacher briefly intervenes in order to clarify to a student the difference between heat energy and heat.

4.3. *Proximity to the form of the referent (formality)*

In visual semiotics, formality is connected to the proximity of the represented figure to the appearance of its referent (e.g., Kress and van Leeuwen 1996: 152; Dimopoulos et al. 2003). Taking into consideration the fact that in a theatrical performance corporeal expressions can be conceived as 'images,' formality is utilized as a notion describing the degree of abstraction regarding the form of what is kinesically performed. In ancient Greek theatre, the posture as well as the shape of the performer's body captured the instantial somatic image of the character and were thus as meaningful as movements (e.g., Valakas 2002). Furthermore, the

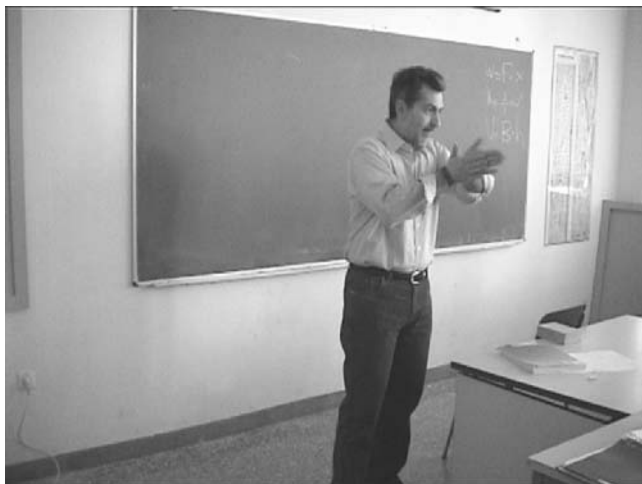


Figure 3. *The teacher rubs his hands together to warm them up (increasing their heat energy), in imitation form*

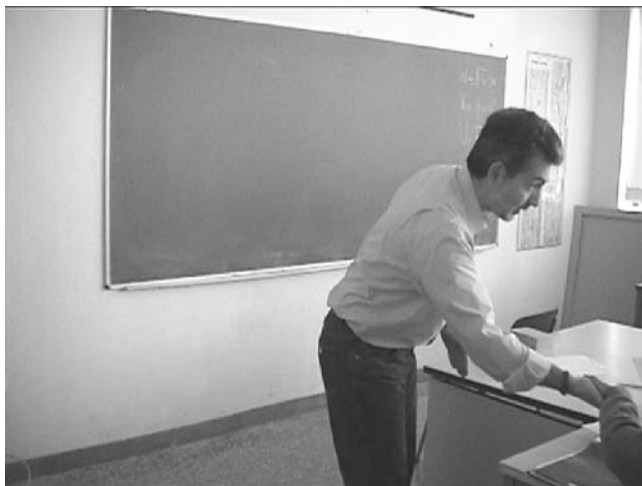


Figure 4. *The student is made aware of the increased temperature and receives the heat. The kinesic form would have been more abstractive if the teacher had extended his hand towards the student without touching him at all. In that case a word-text such as ‘what do you feel?’ would have implied a more imagery-instructional instance.*

(theatrical) image also dominates in Samuel Beckett's dramaturgy. Actually, because of his interest in visual arts, Beckett organized the actor's body around a scenographic perspective in which movement and posture in correlation with spatial components, create visual compositions — images equal to linguistic text (utterances) (Garner 1994: 54).

As has already been mentioned, physical actions constituted a main concern of theatre theoreticians such as Stanislavski, Meyerhold, and Grotowski. In addition, Jacques Lecoq (1921–1999), a theatre pioneer who introduced some innovative corporeal functionalities into contemporary theatre, experimented in depth with the exact reproduction of actions (*Mime d'Action*) occurring in daily life (Lecoq 1997). From a phenomenological point of view, among other things he referred to the capability of the human body to mime a common action with no sense of theatrical transposition. He also distinguished the term *mimisme* (mimesis) from the term *mimitisme* (mimicry). The former corresponds to forms that exhibit the deeper essence of the represented concept while the latter to forms that merely depict it. In the present study, all forms are regarded as figures of *mimesis* conveying different degrees of abstraction, without there being any intention of defining them in correlation to their theatricality.

Hence, as regards iconic gestural signs, the concepts of *imitation*, *equivalence*, and *metaphor* are developed as abstractive forms of mimesis. (Peirce refers to them using the terms image, diagram, and metaphor respectively, e.g., Elam 1980: 21, 24, 27.) Concerning mime, Barba and Savarese (1991: 95–96) distinguish acts according to their capability of containing realistic muscular tensions or not. Consequently, when the human body exerts real muscular tensions (e.g., 'I kick the ball'), the authors use the term *imitative* to capture the experiential aspect of these figures because such acts do not vary from the realistic referent (cf., figures 5 and 6). Besides, they characterize the form as *equivalence* (1991: 96) when it deviates slightly from an exact replica (cf., figures 7–10); the muscular tensions are not the real ones but the body keeps its shape (e.g. 'I kick the space around me'). Eventually, keeping to Peirce's terminology, when the figure ceases to retain any apparent correspondence or resemblance to the referential entity, it is defined as a *metaphor* (e.g., 'I move my body [or my hand] slightly forwards') (Elam 1980: 24, 27) (cf., figures 13 and 14).

4.4. *Relation to the content of the referent*

Referring to Samuel Beckett's dramaturgy, Pierre Chabert argues that in Beckett's plays the body

Table 2. *A human action or activity can be performed by means of imitative, equivalent, or metaphorical iconic gestural semiosis, but the representation of an object or entity and its activity can be conveyed through a moderate or high degree of abstraction (equivalence and metaphor respectively).*

Representation of a human action or activity			
<i>Forms of representation</i>	imitation	equivalence	metaphor
<i>Formality</i>	low	moderate	high
		Representation of an object or entity (and its activity)	

... is worked, violated even, much like the raw material of the painter or sculptor, in the service of a systematic exploration of all possible relationships between the body and movement, the body and space, the body and objects, the body and light and the body and words ... (Chabert 1982: 25)

The relation between action and spatial elements (i.e., scenic objects as well) was stressed by Zich (1931: 227), who noticed that language and movement contribute to the meaning of the setting. In terms of *kinesic spatiality*, the human body can establish spatial modalities representing concrete visual elements of the theatrical performance such as human activities, removable decoration settings, and props (e.g., Fischer-Lichte 1992 [1983]). It is crucial to note that the degree of abstraction of each constructed iconic gestural semiosis is tied to the content of the referent. In this sense, a *human action or activity* (i.e., ‘kicking a ball’) can be rendered through imitation, equivalence, or metaphor, while an *object or an entity* (and its activity) (i.e., ‘motion of the ball’) can only be expressed by equivalent or metaphorical shapes (cf., table 2). In the latter case, the absence of imitative forms is obviously due to the fact that the human body itself cannot perform replicas of material or imaginary objects.

In figures 5 and 6, the teachers imitate human actions in terms of exerting real muscular tensions.

When human actions turn to equivalence then the muscular tensions are not the real ones. Nevertheless, the iconic gestural semiosis does not ruin the outlines of the figures (figures 7 and 8).

As can be done with human actions, forms of equivalence can also be generated concerning objects (figures 9 and 10).

Furthermore, in physics teaching, human actions can alternate with object activities so as to constitute a coherent corpus (figures 11 and 12).

In the case of metaphor, the corporeal image does not directly correspond to the original shape of the represented concept. In proportion to speech rhetorics, a metaphorical form is conveyed when, prior to the current linking, the constructed body-vehicle used to describe another



Figure 5. Imitation: representing a human action. *The teacher's leg exerts force upon the wall in order to introduce Newton's third law. The referent here is the human action 'I kick the wall.'*



Figure 6. Imitation: representing a human action. *The teacher discusses potential energy. He imitates the action 'I pick up the bag.'*



Figure 7. Equivalence: representing a human action. *Teacher 'exerts' force upon an imaginary wall*



Figure 8. Equivalence: representing a human action. *Equivalent representation of the action 'I stretch the bow,' mentioned during a discussion about potential energy storage.*



Figure 9. Equivalence: representing a material object (and its activity). *The teacher follows the horizontal oscillation of a body tied to a spring. In this snapshot he is located at the position of maximum oscillation amplitude.*



Figure 10. Equivalence: representing an imagery object. *His extended left hand refers to an imagery object: 'the arrow indicating the direction of the \vec{F}_1 force.'*

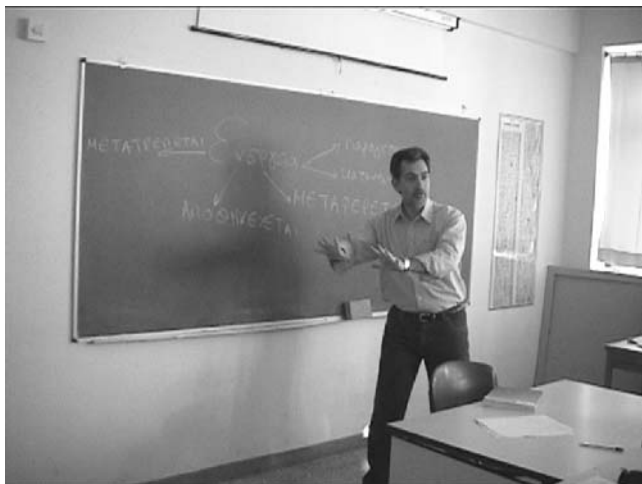


Figure 11. Equivalence: representing a human action. *An equivalent form of the human action: 'I push a trolley.'*



Figure 12. Equivalence: representing the activity of an object. *An equivalent representation of the activity of a material entity: 'the motion of the trolley.'* The motion itself constitutes the salient feature equivalently connecting the teacher's performance with the motion of the trolley.



Figure 13. Metaphor: representing a human action. *The teacher moves his hand cyclically, performing the human activity 'motion of a runner in a circular track.' The same movement could also be used in representing the activity of a material entity (e.g., the motion of a planet).*



Figure 14. Metaphor: representing an entity. *He gesticulates moving his hands up and down in circular movements in order to give students an idea of the 'mixing.'*



Figure 15. *The teacher moves in a quarter-circle equivalent to the human activity 'motion of a runner in a circular track'*



Figure 16. *The teacher moves in a quarter-circle equivalent to the human activity 'motion of a runner in a circular track'*

referent that was better fitted to it visually than the current one. To be more precise, in a metaphor the signifier is charged with another, more abstractive, signified. Figures 13 and 14 depict metaphors in which slightly different conceptual regulations are used for their classification.

Concerning formality, some less abstractive forms of equivalence and imitation can be seen in figure 13. Imitation could correspond to the 'motion of a runner under regular conditions,' which means that the teacher ought to physically perform the motion almost as a real athlete would (which seems impossible to do inside the classroom); on the other hand, what is shown in figures 15 and 16 might qualify as an equivalent version.

On the contrary, for the 'mixture' entity (cf., figure 14) it seems most reasonable to assume that the metaphor is the only abstractive form that can be produced. It is the semantic origin of the 'mixture' itself that does not allow construction of any imitative or even equivalent figures. The 'mixture,' even in its solid state, which consists of grains, assumes the shape of its container. This means that the human body cannot demonstrate a sharply defined outline of it. The only case in which an iconic gestural semiosis could be equivalent to the entity would be if the referent were the 'pot' in the activities of 'mixing of the ingredients' or 'making of a mixture.' But in these instances the referent would be shifted from the 'mixture' entity to the human action 'making of a mixture.' This demonstrates particularly well the way in which some entities or objects need to be included in human activities and actions in order for less abstractive gestural forms to be created.

4.5. *Collaboration with the utterances*

The interaction between gestural signs and speech was first studied on a typical-scientific basis a few decades ago. This interaction occurs frequently in daily life as well as in every type of theatre. In their remarkable study *A Dictionary of Theatre Anthropology: The Secret Art of the Performer*, Barba and Savarese (1991: 130) call attention to the dynamism of kinesic forms. They mention that in the Orient there are certain kinds of theatre, such as the *nritya* Indian dance, in which gestural signs substitute words. In Japanese theatre, not only do these signs merely correspond to lexical items but they can also convey more abstractive meanings. On the other hand, in Peking Opera,² although the actors do gesticulate or assume appropriate postures, nevertheless the gestural signs mainly accompany speech and song (e.g., Wichmann 1991: 360). Finally, in Occidental theatre the functionality of gestural signs is confined to improvisation rather than a preexisting, regulated context (Barba and Savarese 1991: 137).

Aside from specific cases in which body language is the exclusive resource on stage (i.e., dance, pantomime, ballet), sign-systems may exist

in complementary, supplementary (synonymous), or contradictory relations with actions (Quinn 1995: 87). Concerning speech, Pfister (1988 [1977]: 118) discusses the predominance of its appellative function in cases where it identifies the performative aspects of actions, also noting that there exist dramatic texts where utterances merely accompany the non-verbal acts.

Furthermore, the living agents, as subjects creating the theatrical world, either do or do not express by means of the word-text their degree of alienation from what they are physically performing. In Beckett's plays, for instance, language (i.e., utterances) retains its narrative aspect but is gradually subordinated to the physical actions performed (Aston and Savona 1991: 119; Garner 1994: 54).

4.5.1. *Complementation or supplementation.* Gestural semiosis *complements* speech when it carries additional or different information, while it *supplements* speech when it has the same content with a single word or even a short phrase (figures 17–19 and 20–21, respectively). In figures 17, 18, and 19, gestural signs complement utterances. The entire 'text' consists of three parts (in figures 18 and 19 the airplane must be drawn in different — more recent — positions than the original one, as it continues to move). The first and third parts are word-based (cf., the text in quotes) but the second one is exclusively gestural. During this part (figure



Figure 17. 'While the plane is moving, a box falls from it ...'



Figure 18. '...'



Figure 19. 'and here its velocity has two components'

18) the movement of the teacher's hand outlines the parabolic trajectory of the box. So this gesture substitutes the utterance 'the path of the box is parabolic.'

On the other hand, in figures 20 and 21 the gestural signs *supplement* the content of the utterance. The teacher demonstrates the interaction



Figure 20. *'These forces are exerted from a distance'*



Figure 21. *'It is not necessary for the two bodies to come into contact'*

between two charged bodies, identifying the verbal text (cf., the text in quotes) with the gestural 'text.'

4.5.2. *Speaker's alienation from the gestural 'text.'* Even though the body of the dramatic personage performs a concept that is more or less



Figure 22. *The teacher performs the oscillation of a molecule. His left hand remains unmoving, indicating the equilibrium position, while his right hand oscillates.*



Figure 23. *The teacher performs the oscillation of a molecule. His left hand remains unmoving, indicating the equilibrium position, while his right hand oscillates.*

abstractive (i.e., ‘chair,’ ‘wind,’ ‘love’), the actor must keep the role of narrator to himself. He becomes the *subject who brings the action into being*, the person who shapes his body while at the same time keeping a distance from the gestural signifier.



Figure 24. *The teacher performs the oscillation of a molecule. His left hand remains unmoving, indicating the equilibrium position, while his right hand oscillates.*

In figures 22, 23, and 24, the teacher as a narrator accompanies the movement of his hand with the utterance ‘*I force the molecule to oscillate.*’

The use of the first person singular (i.e., ‘*I force*’) clearly declares that the teacher is the living agent generating the action; the speech content is strongly commentative, separating the person (*subject*) from the corporeal version (*subjectification*). In this case it is the predominance of the expressive function of language that essentially builds a closer energetic connection between speaker and utterance; the person emerges as a dramatic figure (*subject*) articulating his own position concerning his actions, decisions and thoughts (Pfister 1988 [1977]: 110).

Consequently, importance is particularly signaled when the expressive function weakens. This means that the speech content will not indicate the teacher as the agent causing the acts, but rather as *the receiver of the action (object)*. Markers such as the first person singular or personal pronouns in the first person singular will not be detected, thus concealing the teacher’s causality (figure 25).

In figure 25, the teacher fixes his eyes on the molecule, indicating it as the significant element, while he continues performing and describing its motion.

When the teacher ceases to use the first person singular (‘*I am*’) he turns to more neutral utterances (cf., see caption in figure 25). In such a case, he perceives himself as a neutral vehicle that corresponds directly to the entity (molecule) (*first degree of objectification*). This linguistic alien-



Figure 25. *'The molecule moves ...' or 'While the molecule passes from the position of equilibrium ...' or 'When you (addressing the molecule) reach the position of total oscillation amplitude, your velocity ...'*

ation directs the students' attention to the visually prominent features of the gestural semiosis.

The molecule becomes the direct focus of attention as soon as the teacher puts himself in the molecule's place using utterances such as 'as *I* move up and down' or 'while *I* go up, *my* velocity,' which actually imply that '*I am* the molecule.' In this respect, the teacher has adopted the properties of the molecule itself (*second degree of objectification*).

Speech can even establish the teacher's objectification, turning him into an absolute personified entity (i.e., a molecule). This is achieved by means of lexical items such as 'while I am moving I interact with the neighboring molecules, forcing them to move' or 'while I am going up, I am dragging you along (addressing another invisible neighboring molecule).' From a semiotic point of view, combinations of linguistic markers that develop the expressive function of speech (i.e., 'I am') with a second object (i.e., 'neighboring molecule') lead to the total objectification of the speaker (*third degree of objectification*).

5. Conclusion: Semiotic orientations to science teaching and learning

The present study suggests a paradigm concerning the visualization of iconic gestural signs in the context of physics teaching. Although the

study's methodological viewpoint centers on the teacher's activity, it is strongly believed that the concepts derived have an essential significance as regards learning. Namely, in our case, by introducing iconic gestural signs into physics teaching, some patterns of communication are identified that can later be included in designing learning activities and tasks.

Consequently, the technical (semiotic) terminology proposed here is of wider theoretical-epistemological value to science education, since this study helps create the prerequisites for approaching teaching and learning in a semiotic context.

Through their unconstrained implementation in the classroom, the iconic gestural signs chosen exemplify how the communicative clarity and dynamism of theatre could be conveyed into physics teaching (e.g., Pantidos et al. 2001; Stinner and Teichmann 2003). Using theatre semiotics as a background seems promising in helping achieve the long-term objective of establishing a kind of sign-centered dialectic between students and scientific entities.

Notes

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1. Brandon (1993: 142) refers to some significant types of Japanese theatre that include 'Shintō-based celebratory dances and sketches (Kagura), Buddhist dances and sketches (Gigaku), semidramatic dances of imperial court (Bugaku), serious masked dance dramas of the samurai class (Nō) and their companion comic plays (Kyōgen), flamboyant commercial urban theatre (Kabuki), commercial puppet theatre (Bunraku), and in this century, modern spoken drama inspired by Western models (Shinpa and Shingek)'.
 2. A form of Chinese opera which arose during the mid-nineteenth century (Goldstein 2007: 3).

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