Embodied Cognition.
Body, movement and sport for didactics

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Corpo, movimento e sport per la didattica

Embodied Cognition (EC) is an interdisciplinary and multiperspective scientific theory whose characteristic, from a cultural and professional perspective, opens up interesting scenarios in the field of psychopedagogy. In particular, a prolific and extremely interesting area of study is now provided by the contribution of EC to the world of didactics (Caruana & Borghi, 2013).
This work is part of this research horizon, investigating how the key principles of Embodied Cognition offer new opportunities to enhance differences in learning processes (Gomez Paloma & Ianes, a cura di, 2014).
Starting from the analysis of the body as a scientific mediator of the learning process on a neurobiological (Rizzolatti & Sinigaglia, 2006) and neurophenomenological (Gallese, 2006) level, the study focuses on the scientific evidence (Margiotta, 2014) that EC can provide to teachers in the field of didactics. It represents a concrete springboard for delineating and validating an "EC-Based" model (Gomez Paloma & Damiani, 2015) to enhance corporeality as a cognitive system and a learning/ contextualization setting for the building of professional skills in the field of education.

Keywords: Embodied Cognition, didactics, neuroscience, body, movement, teaching/learning.

L'Embodied Cognition (EC) è una teoria scientifica multiprospettica ed interdisciplinare la cui caratteristica, riflettendo sotto il profilo culturale e professionale, apre interessanti scenari nel campo della psicopedagogia. In particolare, un fertile ambito di studio, estremamente interessante, è dato al momento dall'apporto dell'EC al mondo della didattica (Caruana & Borghi, 2013).
Il presente lavoro si inserisce in quest'orizzonte di ricerca, indagando come i principi chiave dell'Embodied Cognition offrano inedite opportunità di valorizzazione delle differenze dei processi di apprendimento (Gomez Paloma & Ianes, a cura di, 2014).
Partendo dall'analisi del corpo come mediatore scientifico del processo di apprendimento a livello neurobiologico (Rizzolatti & Sinigaglia, 2006) e neurofenomenologico (Gallese, 2006), lo studio si focalizza sulle evidenze scientifiche (Margiotta, 2014) che l'EC può offrire al docente nell'ambito della didattica. Un concreto trampolino di lancio per delineare e validare un modello "EC Based" (Gomez Paloma & Damiani, 2015) per valorizzare la corporeità come dispositivo cognitivo e come ambiente di apprendimento e contestualizzazione (setting) per la costruzione di competenze professionali nell'ambito della formazione.

Parole chiave: Embodied Cognition, didattica, neuroscienze, corpo, movimento, insegnamento/apprendimento.

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Introduction

This paper aims at defining the intervention area on which to carry out further developments. This scientific and cultural framework has its specific meaning, as the theme of physical and sports activities is transversal by its very nature; therefore, it embraces so-called hard and soft sciences, from Biochemistry to Philosophy, from Physiology to Anthropology, from Neurosciences to Pedagogy, from Psychology to Biomechanics, etc.

For this reason, I intend to orient the reader towards the understanding of how body, movement and sport – as recognized forms of natural and social expressions of a person – can take on an educational and pedagogically meaningful value nowadays, both for the building of knowledge and skills and for a further qualification of the inclusive processes in the context of the ordinary teaching activity.

In this scenario, the paradigm of the Embodied Cognitive Science (ECS) (Gomez Paloma, 2013) emerges with pride, and becomes the scientific, basic and contextual value on which to invest heuristic energies, in order to improve theoretical frameworks in support of the application protocols, develop tests and action research projects, analyze and reflect on the *evidence-based* didactic experiences that can identify it as a successful model.

More specifically, starting from a scientific framework provided for the mirror neurons (Rizzolatti, 2006), the value of corporeality, with which neurons themselves allow phenomenologically the engagement of social intersubjectivity, has developed in a logical and articulated way. The effects of this phenomenon, called Embodiment, opens up new scenarios related to the educational implications arising from the innovative Neuroscientific discoveries (Damasio, 1995; Gallese, 2005). Starting from Pedagogy of the Body and opening the doors to Physical Education, ordinary and inclusive didactics justifies with more significance and repercussion the inclusion of Neurosciences. When the importance of corporeality and emotionality in the meaningful learnings and in the culture of inclusion starts to gain meaning and validity, there's always multimediality. There are questions and doubts about how to work constructively at school. Therefore, doubts remain whether and how to rethink an "*ECS based" didactics* (Gomez Paloma, Damiani, 2015), that is, a didactics that enhances body and movement as integral parts of the educational process.

1. Mirror neurons, corporeality, intersubjectivity: the phenomenon of the Embodiment

An interesting interpretation of the relationship between Neurosciences and Philosophy is provided by the philosopher Hans Jonas who, in his book "*The Phe-*

nomenon of Life: Towards a Philosophical Biology" (1969)[1], carries out a careful reconstruction of the biological point of view with that of social sciences. The psychophysical dualism, the idea of a mind-body separation is, according to the philosopher, a real watershed in the history of Western thought. This dualism has led to that fracture in Western thought, which contemporary thought seeks to recompose. With Darwin's evolutionism the dualist question arises once again, but in reverse: the realm of soul extends once again from the man to the whole realm of life. We get a deeply unitary vision of man with Neuroscientific research that, in recomposing mind and brain, reevaluates the body by using it to explain the cognitive and moral phenomena that the long philosophical tradition has always considered alien to corporeality.

Some important research activities (Glenberg, Havas, Becker & Rinck, 2005; Clark, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005; Harrison, Gray, Gianaros & Critchley, 2010), in fact, have demonstrated the brain functioning, the acting brain functioning. According to the classical theory of the motor brain functioning, the sensory and motor areas are distinct, that is, they are placed in different cortical areas. Associative areas have the task of receiving stimuli from sensory areas, in order to obtain the perceptive data to be sent to motor areas, so that the latter can generate movements and actions. Motor brain is just an executor, as it executes orders from the frontal cortex. This concept follows the model of intelligence developed by Cognitive Sciences: cognition is an autonomous, logical and disembodied process, completely unrelated to corporeal experience. Instead, research over the last years has identified reasons for overcoming this traditional assumption. Some studies have focused on the visual-motor anticipation function for the solution of problems related to the manipulation of objects in space. Neuro-physiologically speaking, the mechanism that regulates the imaginary transformation of objects and their material transformation in the physical space is the same. More specifically, a subject can mentally rotate a solid in space, and thus he\she can make a mental simulation of a moving object, only because the neuronal mechanisms regulating this activity are the same mechanisms allowing him\her to perform the same actions in physical space. Imagining an action is a way to train ourselves to do it actually (Glenberg & Kaschak, 2002).

In terms of evolutionary psychology, the fundamental role of the body in the formation of higher knowledge processes is demonstrated by the role it takes in elaborating the idea of the cause/effect relationship. A relationship that the child understands early, since he\she experiences how some behaviors have specific consequences: he\she cries and is cared for. Therefore, the subject can understand the relationships among concepts and can interpret them in terms of causes and effects, having previously lived the corporeal experience of how specific performed actions are followed by directly related other ones.

The value of corporeality as a precondition to higher-order cognitive processes is demonstrated through research on the structure of the motor areas on the cortex. A complex system of neural relations has been detected, showing that the motor system is not only intended to receive the motor stimuli. Studies of fundamental value concern the F5 and F4 neurons. It has been discovered that F5 neurons (located in the back of the frontal cortex) have visual-motor properties,

1 It. transl.: "*Organismo e libertà. Verso una biologia filosofica*" *(translation by* Paolo Becchi, Einaudi, Torino, 1999)

i.e. they translate visual information about objects into action. This leads us to believe that F5 is a real archive of all possible actions that can be performed in the perceptual-motor activity. In particular, when objects are arranged in a certain way in the perceptual field, showing a specific form and disposition, the brain is able to recognize the situation and choose, in the repertoire of actions, the one it considers more congruent. In this regard, Rizzolatti and Sinigaglia (2006) state that motor brain is able to activate a pragmatic understanding of the objects. F4 neurons are known as bimodal neurons: unlike the normal somatosensory neurons, they are not activated only when triggered by tactile stimuli, but also by visual stimuli produced by objects that occupy their visual receptive field, and are perceived in continuity with respect to the somatosensory receptive field. The function of these neurons redefines the idea of space and objects placed in it. Space is re-interpreted as a system of relationships between our body and the objects surrounding it, and is continually encoded by bimodal neurons, based on the different parts of our bodies, which act as measurement units. Therefore, the space is our way to place objects within our field of action. In light of this, also the conception of the subject changes: it is not the position of something that identifies itself with geometric coordinates, but it is a possibility of action for the subject. On the basis of the distance from the body and its interdependence with the other objects, it is the object itself suggesting how to act in a situation.

Instead, discoveries about mirror neurons, (Gallese, 2006; Rizzolatti & Sinigaglia, 2006), located in the premotor and parietal cortex, reveal the neural mechanisms of sociability and empathy. Mirror neurons have visual-motor properties, like the canonical F5 neurons, but they are mimetic in nature, i.e. they act in relation to actions that the subject sees other subjects performing. These neurons can be classified according to the type of action: an example is represented by the mirror neurons when grasping, holding something tight, jumping. In addition, it was noted that the actions reproducible by the mirror neurons don't involve only the hands but also the mouth. Their function is to be found in the production of internal motor imagery, which supports the process of learning by imitation. Through motor imagery the subject becomes able to plan and perform an action in the way he\she had planned it (Jeannerod, 2007). According to Gallese, one of the most interesting aspects of this discovery is that, for the first time, a neural mechanism allowing a direct passage between the sensory (visual and auditory) description of a motor act and its translation has been identified. Perceiving an action as such, and not as a sequence of movements, implies an understanding of its meaning: it is an inner simulation, because its motor program is activated even if that action is not carried out by the subject. It's a penetration into the world of the other from the inside, with a prelinguistic mechanism of *motor simulation*. Both motor and emotional reflection in the other, the possibility to understand his\her body language, the inner simulation of his\her actions, the prevision of one's own action, are possible thanks to the activation of the mirror neurons.

Further studies have recently clarified another aspect of the social experience: sharing sensations through the touch. Apparently, the subjective experience of being touched on one side of the body determines the activation of the neural circuit, which is activated if looking at someone who is being touched. A single cortical region is activated both when experiencing something first-hand, and when witnessing the same experience of someone else. «[...] The observer's action is a potential action, caused by the activation of mirror neurons that can encode sensory information in motor terms, and thus they can make possible that reciprocity of actions and intentions underlying our immediate recognition of the meaning of

the gestures of others. Understanding the actions of others has nothing theoretical, but it's based on the automatic selection of those action strategies that, according to our motor patrimony, are more compatible with the observed scenario from time to time» (Rizzolatti, Sinigaglia, 2006, p. 127).

Another line of research concerns Psycholinguistics and, in particular, the relationship between corporeal experience and problem-solving related to the semantic ambiguity of some words. In fact, a single verb can designate different situations and emotional states. The ability to distinguish the different meanings and overcome the semantic ambiguity depends on the experiences the subject has lived, i.e. from all the feelings, perceptions and emotions related to the verb-action in the different circumstances. We speak of Embodiment: language comprehension is based on the embodiment of the meanings (Gomez Paloma, Damiani, 2015). When the subjects listen to words or phrases related to actions, the system of mirror neurons is modulated and activates the primary motor cortex. It has been shown that listening to sentences related to actions, performed by means of the hand, specifically modulates the excitement of the hand muscles.

Many aspects of social cognition, on a Neuro-scientific level, show a common functional mechanism, that of embodied simulation (Gallese, 2006), which allows a direct understanding of the motor actions of others from an inner perspective, of some fundamental aspects of the interpersonal relationships, such as emotions, sensations and linguistic communication. So embodied simulation is the precondition for intersubjectivity and empathy.

According to Gallese, embodied simulation results in the generation of the shared multiplicity system. It allows recognizing other humans as our fellow human beings, promotes communication and imitation, as well as the attribution of intentions in others. It is characterized by three levels: phenomenal, functional and sub-personal level. The phenomenal level is characterized by the sense of familiarity and the subjective feeling of being part of a community. These are the conditions for empathy: actions, feelings and emotions of others become meaningful, since they can be shared through a common pre-linguistic neural representation format. Performed actions, emotions and feeling experienced by others gain meaning for the interlocutor, because of the possibility he has to share them experientially thanks to a common representational format. A we-centric sharing defined by Gallese (2007) as "intentional consonance". The functional level is represented by "embodied simulation" itself, which is the method of the "as if" applied to the world of others, allowing to create self/others models. The same functional logics, underlying the control of one's own actions and experience, also play a role in the understanding of others' actions and experiences. Both are expressions of interaction models, which classify their referents on identical functional relational nodes. Each method of interpersonal interaction shares a relational character. The sub-personal level consists of a series of neural circuits connected to a series of corporeal changes of state. All these aspects of intersubjectivity rely on the co-building of an intentional consonance, which starts with the first interpersonal relationships, shortly after the birth, and accompanies the individuals throughout their life. This system founds and promotes the process of mutual intelligibility.

2. Pedagogy of the body, Neurosciences and Motor Education: didactic implications

The segmentation and specialization that characterize the current state of knowledge, the struggle and the absence of communication between the sciences, the difficulties of interdisciplinary comparison, linked to the challenges of the complexity of the globalized society, require a reorganization of school and its guidelines, with the superseding of a teaching method that tends to isolate the objects of knowledge. «And yet we call knowledge what is able to fit into a wide framework, assessing and producing proposals, asking how it is able to change or transform the structure of this framework itself ... an intelligence that is used to make analyses according to separations reduces the opportunity to understand the long-term responsibility, the planetary reference of any act of knowing» (Gamelli, 2001, p. 10).

Recomposing the fragments in a unity occurs in the body, thinking of oneself and others starting from corporeality becomes the core hub of Pedagogy of the Body, which critically revisits the educational common scenarios, where the body is often absent or harnessed for integrating knowledge and experiences traditionally separated: those of the word with those less recognized of movement, gesture, sight and senses. An interesting aspect is the transfer, in the different educational fields, of the principles underlying the corporeal education in its various forms (such as psychomotricity, dance, techniques of relaxation and use of the voice, theatre, as well as the multiple treatment methods and corporeal-mediated artistic formative technologies). Pedagogy of the Body shows a pedagogical feature, where research on the body is smoothly combined with the narrative educational strategies. An approach that is not interested only in the execution, but that mainly focuses on the relationship. Therefore, the body becomes an educational subject, it is not only a part of the knowledge process, but a knowledge-producer, because it's an experiential-type learning.

Experiential-type learning plays a central role in physical education, which enhances movement-related practices. From a psycho-pedagogical view sport is deeply educational, since it conjugates physical dexterity and ability with competitiveness, but in a meaning frame based on the respect for the opponent: a self-affirmation with respect for the other. The purpose of motor activity, in psycho-pedagogical terms, is both to develop and strengthen the body and to develop a social and ethical personality, based on the values of respect, humility, sacrifice, sharing of the joy and of the team spirit. The formative approach of this discipline is holistic, because it allows the formation of a solid (both personal and social) identity, starting from the idea of a unique and unrepeatable corporeality orienting the subject, in developmental age, towards the acquisition of a balanced way of being in the world. In this case, we speak of resilience as «the human ability to face the adversities of life, overcome them and come out stronger or even changed» (Grotberg, 1995). Resilience means optimism, fortitude, sense of self-worth and self-competence, hope, empathy and availability, independence, relationality, initiative, creativity, morality (Gomez Paloma, 2009). All variables boosted by motor education and usable in everyday life. In addition, perception, verification and comparison, immediate aspects of one's own action in the motor experience, allow for the development of both the self-regulating skills and of the sense of self-efficacy, bringing affective, emotional and corporeal processes into play. Finally, in allowing the feeling of the contact with self-corporeality, motor

education enhances the understanding, production and expression skills through the analogical language of the body.

Starting from this interpretation of Pedagogy of the Body, the educational value of motor and fun-sports activities has been decisively revalued, thanks to progresses in scientific research in recent decades, expanding the scope of the corporeal experience and highlighting its unavoidable intertwining with the emotional dimension and the cognitive processes (Gomez Paloma, 2004). In particular, the contributions from the field of Neurosciences and Psychobiology now provide possible interpretations on the complexity of the individual dimension, the relationship between subject and learning, trying to shape didactic intervention, reintroducing different information enriched by the inventory of possible sensory stimuli linked to it, requiring the body and the movement to become protagonists in the teaching-learning process.

The discrepancy between theory and practice, typical of education in general and particularly felt in motor education, is a cultural heritage. In the nineteenth century, the sharp distinction between theory, intended as knowledge, and practice, intended as production of artifacts, has been highlighted (Luhmann, 2005).

Therefore, the theory-practice dualism originates from the mind-body dualism. This separatism is typical of the disciplinary concept inherent in the nature of school. A vision that, as previously pointed out, arose in classical Greece, was stressed by Descartes and has reached our times, and despite the discovery of an embodied mind (Gallese, 2007) and the awareness of a mind-body unity, the educational practice still acts as if the dichotomy was an essential truth.

However, theory and practice are closely linked as they are part of the same teaching-learning process, and moreover, at times, theory is needed to outline a good educational practice, and other times, from this educational practice, the most comprehensive theories originate. In the field of motor education this relationship of proximity between theory and practice is particularly clear, since the learning process occurs by means of the action, leading to a change.

In order to develop a unitary knowledge and relevant abilities, offering a horizon of meaning to the knowledge fragmentation (Acone, 2005), arousing students' curiosity and pushing them towards the marvels of knowledge, it is necessary to adopt a meaningful, and not a mechanic, learning.

Precisely because the body allows to act, it becomes a knowledge\abilities\resources-builder, as its continuous development and language are intelligent and convey feelings, emotions and thoughts better than other codes; this is what creates the substrate of intermediate and advanced learnings, which are essential to symbolization, classification and abstraction processes (Gallese, 2005).

Therefore, in this sense, motor education is a discipline that, due to its global nature, aims at the development of all aspects of the areas of learners' personality: the affective-emotional, intellectual, social, motor and organic areas, which are all closely linked and interdependent. It is therefore a transversal discipline that allows getting ready for the acquisition of learning. In addition, it allows the learner to understand the objective to be achieved, since he\she's given the indications, which can be connected to his\her previous experience and knowledge, from which to develop actively his\her own way of acting by achieving the goal, although each learner will develop a personal style for doing it. It's a discipline that allows a learning-by-actions process through the movement: two actions, two movements, though belonging to the same basic motor schemes, will never be identical as the physical conditions of who performs the action change like the sensations from the outside, the context within which the actions take place, the felt emotions, the tasks given by the teacher, the space in

which to perform these tasks, the ways of approach, the words used by the teacher. Moreover, different movements activate different neural groups, increasing multiple neural networks and reducing the risk of *neural groups selection* (Edelman, 1993), since some nerve groups weaken and eventually disappear if not stimulated.

Finally, it is important to remember how and to what extent motor education, in facilitating the development of an awareness of one's own body, the perception of one's own body, the feeling of one's own movements and actions, the fact of living oneself as a unit, becomes a fundamental discipline for the dissemination of positive values, especially of the model of care and respect for one's own body. Core values when considering that today, in the media society, with television that by replacing parenting at different times of the day, the subject in developmental age undergoes a bombardment with images of phagocytizing bodies, bodies distorted by surgery, mortified by eating disorders, reified and exploited for advertising campaigns, where image counts for everything. In this sense, motor education and Pedagogy of the Body, in dealing with those scaremongering psychosocial phenomena, become a stimulus to plan the educational intervention responsibly.

3. Rethinking didactics: a possible dialogue between Embodied Cognition and Multimediality

Neuro-scientific studies have shed new light on learning modes, cognition and social relationships, focusing their analysis on the body and its extraordinary learning abilities, as well as on the corporeal experience as the core device for knowledge production. On this basis, it is necessary to rethink traditional didactics, a literary didactics centered on the mind and not on the body, in favor of a corporeal didactics. Traditionally, indeed, teaching is considered as a set of logics, generalizations, principles, rules, abstractions, borrowing the cognitivist idea according to which mind works like a computer. A didactics, in exchange, that considers the importance of the experiential learning or a routine learning activity does not deny the importance of the generalization or of the development of the abstraction abilities, but it links and builds them starting from the child's most meaningful experience: the corporeal experience of the world. Paul Gee (2010), professor at Arizona State University, and leading exponent of the new area of research known as New Digital Media and Learning, argues that a good way to make a learner feel inadequate is asking him\her to learn to think according to abstractions and verbalizations, excluding those situations that belong to his\her corporeal experience of the world from school learning activities. Unfortunately, this is precisely what we do regularly at school. Essentially, according to the scholar, the reading-writing skills gained by means of the alphabetic writing are not the only literacy skills to make students acquire, especially in the light of their condition of "digital natives" in the information society. Gee, in particular, focused on the relationship between videogame and learning, dispelling, first and foremost, a counterproductive myth: the casual use of the videogame at school. This methodological confusion generates two types of contradictions: first of all, once become formal, it semiotically becomes another object as its semiotic domain includes a specific grammar, a specific language and specific rules, which belong to the world of informality; in addition, many traditional teachers tend not to embrace a technology designed and characterized as "a game" (Rivoltella, 2012). The inclusion of the videogame in teaching practices may fall within the didactic laboratories,

thus it would have the goal to make students discover the methods through which, in that specific world, the world of the videogame, the players achieve learning. In this case, learning takes place in a specific semiotic domain, that is, in a peculiar meaning frame, precisely that of the videogame, in which words, images and symbols acquire a meaning. On an educational and experiential level, the key point of interest is represented by the different identities that the learner shows in this unique teaching-learning setting. In fact, during the game, the subject employs three types of identities: the corporeal identity, that is, the real identity; the virtual identity, that is, the character to be played in the game; the projective identity, that is, the self-projection in the game. The type of learning that the subject achieves deals with his\her three identities and the domain organization: he\she is challenged by contents and rules, intrigued by the internal grammars, puts himself\herself to the test with respect to the three identities, plans and develops actions and strategies. The semiotic traces in the video game are a call for the subject to the embodied action, according to Gallese's definition, and the meanings are always continuously located and built up by the player (Rivoltella, 2012). Such an integrated approach can include the disciplinary contents, just because the disciplines are semiotic domains too. However, it should be emphasized that not all disciplines are fully suitable for the stimulation of socio-relational skills, as the related social practices can be very scarce and, at the same time, for some disciplines, there would be no identification with the character, hence there would be no corporeal experience making for the building-up of located meanings. These latter are not built up, in fact, only by means of verbalization, but they're realized when a word may be associated with an image, an action, an experience; however, if there's no such an association, the student can pass a test mechanically, but he\she won't be able to apply that knowledge in a real problem, or better, he\she will have difficulties in developing a real skill (Gee, 2010). Videogame, while not being the right recipe for the "embodied-type" learning, however, suggests the school system a rethink of the way we teach at school, since learning doesn't mean storing a definition, but it means building up a series of skills-experiences to be employed strategically, in order to predict how to behave in similar situations.

If classical videogames do not seem to be the ideal tool for an "embodied teaching", it should be noted how precisely videogaming generates some trends that are making users go beyond the screen, the barrier that relegates to the world of representation what is happening on the other side of the display. The involvement of the bodily experience, historically denied in the world of classical game, is realized in the last videogame generations thanks to devices and media that can give movement to the human-computer interaction. Examples include the worldwide spread of the Nintendo Wii console (equipped with a joystick with an accelerometer and a gyroscope, able to communicate the position with respect to a sensor installed on the screen), the success of Microsoft Kinect (a device that combines several types of cameras and that can locate the user's movements) and forms more or less evolved forms of virtual reality dedicated to the consumer market (the display Oculus Rift , for example). The common feature of these technologies is the ability to enhance movement in the human-computer interaction. When the entire body becomes the protagonist of the interaction, the domain of representation is replaced by that of embodiment. With Hansen, in fact, "motor activity – not representationalist verisimilitude—holds the key to fluid and functional crossings between virtual and physical realms" (Hansen, 2006). Trackers, gps, gyroscopes, accelerometers, bio-sensors embedded in smartphones or available as wearable devices become the protagonists of this new paradigm, called NUI (Natural User

Interface) as they can exploit the natural mechanisms of human interaction (movement, touch, voice) in the interaction with machines. Gee's intuition is fully realized; in fact, that already in 2008, he defined videogame a "goal-directed action-and simulations of embodied experience" (Gee, 2008).

This paradigm shift is not just about the world of video games, but in general all the digital universe. Smartphones and portable devices are normally equipped with hardware that can detect movement (accelerometers, gyroscopes, gps) and share a general tendency to natural interfaces (think of the pinch and swipe, the most common gestures of interacting with operating systems for mobile devices, or voice-controlled applications to use while driving). Anyway, it's an announced revolution. Again with Hansen, we remember that «Merleau-Ponty's phenomenology of embodiment is, from the beginning, a philosophy of embodied techniques in which the excess constitutive of embodiment the horizon of potentiality associated with the body schema—forms a ready conduit for incorporating the technical at the heart of human motility» (Hansen, 2006).

Therefore, the technology incorporated into the heart of human movement. Everywhere, but not at school. The paradigm shift towards natural interfaces has only nearly achieved school. Also the technologies spread in schools and able to realize a high involvement of the body in the interaction (think, for example, to the endless galaxy of smartphone apps or the unusual combination of touch screen and large dimension of the Interactive Multimedia Whiteboards) were subject to a process of reduction and adaptation to the model of the "sit down and pay attention!". In fact, the Interactive Multimedia Whiteboards has been promptly reduced to the status of a video projector, or better, it has been subject to an appropriation according to the operational frame of the 1.0 lesson (super-instrument of representation that assists the teacher in his face-to-face didactic activity)" (Rivoltella, 2009). This phenomenon can be understood if considering technologies as a neutral and ipso facto representative element of innovation, but as an element which provides a precise interpretation of the teaching activity. With Calvani, «ICTs become one of variables within a composite context, which is always, in one way or another, educationally (and ideologically) oriented» (Calvani, 2009). A school that remains anchored to a model of face-to-face didactic activity, or that struggles to draw up a global framework for understanding embodiment in relation to didactics (therefore, that struggles to define operational strategies), will continue to inhibit the interactive element (whether it's human machine interaction or interaction between individuals) just because there is a direct link between interaction, embodiment and participation: in fact, it denotes a participation status, the presence and the occurrence of a phenomenon in the world. Conversations and actions are embodied like tangible objects. For example, conversations are embodied phenomena because their structure comes from the way they are developed by the participants in real time and under the immediate constraints of the environment in which they take place (Dourish, 2004).

Within this framework, there should be a special mention to the relationship between movement didactics and technologies. In fact, technologies based on natural interfaces are gaining space, except for classrooms, at least in gyms. The spread of technologies that detect and arrange a wide range of real-time data about the athlete and context in sports offers a great opportunity to collect performance data, enabling an objective, accurate and non-invasive monitoring of physical activity and avoiding any interference related to the laboratory settings. This phenomenon is pushing also users that are not related to professional sport to greater confidence with the collection and analysis of quantitative data, and is supporting

an increasingly pronounced "social" component of sports, which leads athletes (and teachers) to share and comment on social networks their performances, based on data collected via apps (Di Tore, 2015). Helmer et al. explicitly connect the ability to capture performance data with interactive coaching models: «Wearable devices extend the body in a real and virtual manner. The flow of information and stimuli from real - to - virtual, and virtual - to - real enable experiences to be shared across time and space. Wearable devices using textiles with embedded physiological sensors are used in various applications involving monitoring, control and learning» (Helmer et al., 2010).

The lesson to be gathered from Neuro-scientific research emphasizes the role of the repertoires of actions and mirror neurons. In the learning by imitation process, the modeling, a person learns by observing: a modality that hardly lends itself to the theoretical knowledge. However, if the teacher does not explain lessons with words but he\she solves problems, interprets, analyzes in front of the class, he\she succeeds is being observed while putting knowledge in practice. In such case, he\she serves as a model, and his\her work serves as model- experience. Finally, the imitation of the model allows the subject to build new action patterns. Rethinking didactics, taking into account the contribution of Neurosciences, means also rethinking the educational relationship from an empathetic standpoint. A relationship that is no more asymmetric between the teacher and the student, but it's revisited in the light of the emotional reflection and resonance allowed by the neural system. Empathy also allows the teacher to get in touch with the student, especially with the more problematic one, without losing his\her own "self " but putting it at the other's disposal in a mutual exchange, avoiding any confusion of roles. As stated by Gomez Paloma «... being reflected in the other starting from myself does not mean going along with him\her or adopting his\her own characteristics and attitudes for an ambiguous use, but for turning them into tools for reflection for the person who asks for help. It's a way of lending oneself to act as a mirror that allows the student to understand by himself\herself what are the attitudes or behaviors leading him\her to do or say certain things or to experience certain behaviors. Therefore, the purpose of corporeal didactics must be that of providing each student with the tools for educating himself» (Gomez Paloma 2004, p. 187).

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