Body, movement and educational robotics for students with Special Educational Needs

Paola Damiani • Università di Torino – paola.damiani@unito.it
Antonio Ascione • Università degli Studi di Napoli "Parthenope" – antonio.ascione@uniparthenope.it

Corpo, movimento e robotica educativa per gli studenti con Bisogni Educativi Speciali

In this paper, we present some topics to improve the use of Robotics in teaching, with a new approach of Embodied Cognitive Science (ECS) (Gomez Paloma, 2013) in order to facilitate learning of all students. The notion of simulation (Gallese, 2005b; 2009) has assumed a central role in the theories of the embodied cognition; in particular, it's made reference to the motor simulation during the observation of objects or people performing an action, and the comprehension of a language. The learning experience with the robot is characterized as a relational experience that is essentially different from that with a computer or another electronic device. Attention for body and movement through Robotics stimulates development of basic skills and capacity for learning, as visuo-spatial, visuo-motory and social skills; these skills are very important for students, especially for students with Special Educational Needs.

Keywords: Intersubjectivity; Body; Movement, Learning and Teaching; Educational Robotics, Special Educational Needs

L'articolo presenta alcuni argomenti connessi all'utilizzo della robotica nell'insegnamento, attraverso la prospettiva dell'Embodied Cognitive Science (ECS) (Gomez Paloma, 2013), al fine di facilitare l'apprendimento di tutti gli studenti. La nozione di simulazione (Gallese, 2005b; 2009) ha assunto un ruolo centrale nelle teorie della cognizione incarnata; nell'articolo, si farà riferimento particolare al processo di simulazione motoria che si verifica durante l'osservazione di oggetti o persone che eseguono un'azione e la comprensione di una lingua. L'esperienza di apprendimento con il robot si caratterizza come un'esperienza relazionale che è sostanzialmente diversa dall'esperienza di apprendimento con un computer o con altro dispositivo elettronico. L'attenzione per il corpo e per il movimento attraverso la Robotica stimola i processi di imitazione e lo sviluppo delle competenze di base e delle abilità essenziali per l'apprendimento, quali le abilità visuo-spaziali, visuo-motorie, linguistiche, empatiche e sociali. Queste competenze sono molto importanti per tutti gli studenti, ma lo sono maggiormente per gli studenti con Bisogni Educativi Speciali.

Parole chiave: Corpo; Movimento, Apprendimento; Robotica; Bisogni Educativi Speciali

Body, movement and Educational Robotics for students with Special Educational Needs

1. The role of technology in the creation of inclusive learning environments: the multifunctional educational value of Educational Robotics[1]

Piaget's theory of Constructivist learning has had wide ranging impact on learning theories and teaching methods in education and is an underlying theme of many education reform movements[2].

Constructivist conceptions assume that knowledge is individually constructed and socially co-constructed by learners based on their interpretations of experiences in the world. Since knowledge cannot be transmitted, instruction should consist of experiences that facilitate knowledge construction (Jonassen, 1999, p. 217). According to the constructionist conception, the complex nature of the knowledge-building process requires the immersion in a learning experience in an equally complex context of a rich variety of opportunities, stimuli and resources that Jonassen et al. (1995) define "learning environment". The model for designing constructivist learning environments (CLEs) engages learners in meaning making (knowledge construction) (Duffy and Jonassen, 1992; Jonassen, 1997; Jonassen, Campbell, and Davidson, 1994; Jonassen, Peck, and Wilson, 1998; Savery and Duffy, 1996). A learning environment, to be such, must represent a set of resources supporting the learning task, a place where people, who are there to learn, can work together and support each other while using a variety of tools and information resources in their task of achieving the learning objectives, and solve problems (Wilson, 1996). Therefore, an inclusive learning environment, by extension, should ensure the availability of resources for which all people, even those with disabilities and fragilities, actively participate together (co-participate) and achieve their learning and problem-solving objectives.

Then, the redefinition of schools as inclusive learning environments, according to the constructionist models, opens up interesting perspectives also (and especially) for students with Special Educational Needs (SEN); the use of technologies in education helps to stimulate motivation and facilitate learning (Besio, 2005, 2010; Zambotti, 2013).

Seymour Papert, Piaget's collaborator, has highlighted the importance of providing children with the right tools for learning, naming them "cognitive artifacts". A cognitive artifact is an object or a concrete process allowing the construction of valid mental models, through direct action. According to the author, the cause of the child' slow development of a concept is the impossibility of working directly

1 In this article (particulary, section 3, at the end) there are references to an previous publication of the authors: Damiani P. (2015), TCR e scuola: dallo strumento alla didattica, Chapter III, in R. Grimaldi (a cura di), "A scuola con i Robots", Bologna, Il Mulino.

2 http://sydney.edu.au/education_social_work/learning_teaching/ict/theory/constructivism.shtml

with a cognitive artifact that makes that concept tangible. The performance of learning activities or tasks through such means leads the subjects to develop their intellectual abilities: the effective learning is achieved by means of something that can be "shown, discussed, examined, explored and admired" (Papert, 1993, pp. 142-143). The use of artifacts – and, in particular, of technological artifacts – allows to offer the most successful learning with a minimum teaching activity (Papert, 1980, 1993).

However, in order to ensure the best learning conditions for all students, it also needs to overcome the idea of technology understood in an almost "miraculous" sense, as non-critical and non-contextualized, or the idea of the media as "knowledge conveyors" In order to be authentic and meaningful learning facilitators (and not of empty, mind-numbing and addictions-generating pastimes), it needs to ensure that students learn "with" technologies, and not "from" technologies (Jonassen et al., 1995). The role of hi-tech is more indirect as it can stimulate and support (not replace) the active and direct cognitive-learning process developing between students and peers\teachers; therefore, technologies become "cognitive tools", which are successful and inclusive only in relation to their functional use. In particular, according to Papert, a computer, when mechanically not used for carrying out repetitive exercises, stimulates children's creativity and brings out their individuality, respecting their differences. Obviously, technologies are tools for conveying contents; considered singularly, they are not enough to determine the students' learning activity, as well as the teacher's activity is not enough without an interaction with students. Knowledge is acquired through constructive processes, it is facilitated by collaboration and is determined by the context (Jonassen et al., 1993). According to this model, students do not learn by reading or listening, but need to be involved in activities having cognitive factors able to force the learner to think, discuss, use and train his\her own cognitive skills and resources. The key variable is to set meaningful learning objectives through appropriate tools, which force students to apply themselves in problem-solving processes\actions.

For what concerns students with SEN (Special Educational Needs), it is important to remember that technologies, as *cognitive tools*, do not make it easier to learn in an automatic and deterministic way. As Jonassen highlighted, a critical characteristic of meaningful learning is mindful activity. In this sense, they are instruments of reflection that amplify personal cognitive skills (Jonassen, in Marconato, Litturi, 2005, pp. 17-18).

In order for learners to be active, they must manipulate something (construct a product, manipulate parameters, make decisions) and affect the environment in some way. Activity theory describes the transformational interactions among the learner, the object that the learner is acting on, and the signs and tools which mediate that interaction. "The form of the problem manipulation space will depend on the nature of the activity structures the CLEs is engaging. However, it should provide a physical simulation of the real-world task environment, that is, a phenomenaria (Perkins, 1991). Phenomenaria, or microworlds, present a simplified model, along with observation and manipulation tools necessary for testing learners' hypotheses about their problems" (Jonassen, 1999, p. 222).

Technologies as cognitive tools require the learner to endure the mental strain and the uncertainties, and to think more deeply about the concepts of the study. The cognitive tools and computers are tools for analysis and cognitive amplification helping students to build their own reality; furthermore, each type of tool requires the realization of different educational models. In general, we can therefore say that the constructionist learning environment, through the "pedagogical" use of the technological artifacts, allows to take due account of the comprehensive development of the student's personality, or better, of the relational, emotional, physical and motivational aspects of learning, as well as those intellectual, material and contextual, according to a community and ecological vision, and allows at the same time to observe and appreciate the individual differences (Damiani P., in Pavone, 2015). Among the technologies for learning, as evidenced by Papert, the robot can represent an effective cognitive artifact, able to significantly change the teaching activity. Indeed, Robotics, the "science of synthesis" that brings together mechanics, electronics, information technology and education, enhances the contemporary student's learning potential, in contrast to a school still imprinted on passivity (Papert, 1972; Marcianò, 2013).

> Educational Robotics (Leroux, 1999) stands as a new field of educational research that, starting from the elaborations of the constructivist paradigm, subsequently changed by Papert's constructionist approach, considers robotic technologies as *objects-with-which-to-think* (Harel e Papert, 1991) (Caci, D'Amico, Cardaci, 2007).

The vanguards of school have understood Educational Robotics as a challenge and a chance to create new ways of teaching, according to socio-constructionist paradigm (Ackermann, 2001); robots become the means through which to carry out, in many ways, "innovative and effective" lessons of mathematics, history, physics, literature, english, geography...

Students learn actively, discover the teamwork, experience the problem solving, have the ability to independently find out the mistakes and then correct them. The learning-by-doing is an extraordinary possibility to facilitate learning and improve its effectiveness over time. Recent studies and researches attach to Educational Robotics a function of promotion and support to inclusion (Besio, 2009; 2010; Alvarez, Rios, Adams, Encarnação, & Cook, 2013; Pennazio, 2015). Robotic systems can be a valuable tool for children with special needs to learn through play interactions and can help them to reach the developmental steps of their chronological and/or mental ages (Besio, 2001); there have been many examples of robots being used to involve children with special needs in play activities for therapeutic or educational purposes (Ferrari, Robins, Dautenhahn, 2009).

For example, children with learning disabilities and mild intellectual disabilities can find learning facilitators in Educational Robotics and in the manual activity, while for children with autism they represent an appropriate environment to their educational and teaching needs.

Autism spectrum disorders are a group of lifelong disabilities that affect people's ability to communicate and to understand social cues (Scassellati, Admoni, Matarić, 2012). Robots have already been used to teach basic social interaction skills using turn-taking and imitation games (Dautenhahn, 1999). Robots seem to improve engagement and elicit novel social behaviors from people (particularly children and teenagers) with autism.

Robot therapy for autism has been explored as one of the first application domains in the field of socially assistive robotics (SAR), which aims to develop robots that assist people with special needs through social interactions (Scassellati, Admoni, Matarić, 2012).

Generally, robots can provide a safe and predictable playful environment for children with autism to enjoy and interact with (Dautenhahn and Werry, 2004), moreover, use of robots as therapy tools has shown positive impact also in learning process.

A research of the University of Birmingham has shown that robots could be used to improve the children's basic learning skills. The school is using robot in many activities as a model for the children's behavior, like in memory games, which get the children to imitate the robot's movements, can help them become engaged and motivated with learning. School is using robots also to teach phonics and play cards or memory and imitation games with children aged from five to 10; robotics can contribute to releasing working memory capacity (Howard-Johnes, 2009).

It seems that children find robots less threatening than people as they are more predictable.

Working with a robot also helps to allow languages barriers, facilitating the learning activity (with gesture and movements) fostering the participation of foreign children, who find a place where to learn without the burden of having to follow lessons passively in a language that they find difficult to understand, especially in the early years of schooling.

For these reasons, in recent years the experiences of Robotics applied to the teaching-learning processes have multiplied in European countries, even if they are still unknown by the majority of teachers. Some researches carried out in Italian schools (school classes aged 3-6 and 6-11) have recently shown that the approach of Robotics can be intended as a means of development, recovery and strengthening of some basic skills essential for learning and development – like visuospatial capacity and working memory capacity – and may play a preventive role for some Neurodevelopmental Disorders, such as Specific Learning Disorder, motor Disorders, Developmental Coordination Disorder, attention-deficit / hyperactivity disorder (ADHD) and the autism spectrum disorder (ASD) (Damiani, Grimaldi, Palmieri, 2013; Damiani P. in Grimaldi, 2015).

As neuroscientific research has shown, multimodal stimulus produces additional brain activity over and above that produced by experiencing each mode separately (Beauchamp et al 2004a; 2004b). Technology and robotics stimulate learning and sensorial different modalities. Educational Robotic is a ludic and creative activity, and creativity is considered a key thinking skill; however, in the classroom has been hampered by a lack of understanding of the thinking processes involved. Interdisciplinary studies are analyzing more deeply the elements and dynamics that characterize the learning and teaching-learning processes in the typical and atypical development, in respect to didactics and environmental factors.

The neuroconstructivist approach (Levine, 2004, Kamiloff-Smith, 1992; 2007) considers environmental factors important for their effects on the cortical plasticity of the neurocognitive system. The study of such effects (of different rehabilitation methods) could provide important information about the causes of disorders, highlighting the causal relationship between trained function and disorder. According to this approach, comorbidity (coexistence of multiple disorders) between different developmental disorders would explain the complexity of the causal relationships between them, contrary to some biological approaches that consider disorders according to monofactorial models. These studies have, for example, helped highlight the monofactorial and probabilistic nature of neuropsychological dysfunctions underlying Learning Disorders (Pennington, 2006), and allow for a re-evaluation of the characteristics of disorder "specificities" (basically, they wouldn't be so specific like other acquired disorders) and new possibilities of prevention, at least when disorders become evident.

In this paradigm, robotics became an environmental factor that can improve the development and learning processes in typical and atypical development. Robotics as developmental factor and educational factor.

Researchers who have been analysing the best ways to use the robots say the key is in the programming (Burns, 2012).

2. The role of the body and movement in the learning process. From Neurosciences to the Pedagogy of the Body and Movement

Neuroscientific studies have shed new light on the learning modes, cognition and social relations, focusing their analysis on the body and its extraordinary learning abilities, as well as on the corporeal experience as the core device for the knowledge production (Gomez Paloma, 2004; Gallese, 2006; Gamelli, 2011; Uithol, Gallese, 2015). 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 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.

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 – skills – and 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 learning, which is essential to the symbolization, classification and abstraction processes (Gallese, 2005b). The discoveries about the mirror neurons, (Gallese, 2006, Rizzolatti & Sinigaglia, 2006), located in the premotor and parietal cortex, reveal the neural mechanisms of sociability and empathy (Iacoboni et. al, 1999; 2005; Gallese, 2007). The mirror neurons have visuomotor properties, but they are mimetic in nature, 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 learning by imitation, the learning by doing, according to constructivist model of learning. Through the motor imagery the subject becomes able to plan and perform an action in the way he 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 transition 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 pre-linguistic mechanism of motor stimulation. Both the motor and the emotional reflection in the other, the possibility to understand his\her body language, the internal simulation of his\her actions, the forecast of one's own action, are made possible thanks to the activation of the mirror neurons. Understanding emotions in others is very important for development and learning.

> The discovery of mirror neurons and of other mirroring mechanisms in the human brain shows that the very same neural substrates are activated when these expressive acts are both executed and perceived. Thus, we have a neurally instantiated we-centric space. I posit that a common underlying functional mechanism – embodied simulation – mediates our capacity to share the meaning of actions, intentions, feelings, and emotions with others, thus grounding our identification with and connectedness to others. Social identification, empathy, and "we-ness" are the basic ground of our development and being (Gallese, 2009, p. 520).

Some authors suggest a mirror neuron dysfunction in children with autism spectrum disorders (Dapretto et al. 2006). The embodied simulation model (Gallese, 2005; 2009), which stems from recent neuroscientific evidence, has illustrious philosophical antecedents, but Gallese is challenging the notion that the sole account of interpersonal understanding consists in explicitly attributing to others propositional attitudes like beliefs and desires, mapped as symbolic representations. Before and below mind reading is intercorporeity as the main source of knowledge we directly gather about others (Gallese, 2007). In this model, intercorporeity describes a crucial aspect of intersubjectivity. The recomposition of 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 (Contini, Fabbri, Manuzzi, 2006; Gamelli, 2011; Gilbert, 2012), 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 ones of the movement, the gesture, the sight and the 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 the research on the body is smoothly combined with the narrative educational strategies. An approach that is not interested only in the performance, but that mainly focuses on the relationship[3]. Then, the body becomes an educational subject, it is not only a part of the knowledge process, but it is a knowledge-producer, because it's an experiential-type learning.

Neuroscientific 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, instead, 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,

3 (http://www.pedagogiadelcorpo.it/).

means also rethinking the educational relationship from an empathic standpoint. A relationship between the teacher and the student that isn't symmetric, but it's syntonic, may be revisited in light of the emotional reflection and resonance made possible by the neural system, to enhancing benefits. Empathy also allows the teacher to get in touch with the student, especially with the more problematic one, without losing his own "self" but putting it at the other's disposal in a mutual exchange, avoiding any confusion of roles. "Immediate understanding of others' emotions is the necessary prerequisite for that empathic behavior that underlies a large part of our relationships" (Rizzolatti & Sinigaglia, 2006, p. 181).

In this framework, empathy, corporeity, emotion and cognition are strictly interrelated; have good relationships – as a social experiences – is the condition to realize good teaching-learning processes in the classroom.

Further studies have recently clarified another aspect of the social experience: sharing sensations through the touch. Apparently, the subjective experience of being touched on a part 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. Neuroscientific research has shown us the importance of the feedback: through the latter, the association between experience and a certain synaptic organization strengthens and the forecast system refines – by trial and error – on which our knowledge is built.

The one-to-one teaching, the immediate and specific feedback on the learning level and the tutorial teaching are specific emerging indications of work: the best learning outcomes are obtained when setting up a relationship of individual or tutorial training (Rivoltella, 2013). In particular, the researches are moving towards the recognition of a "fundamental" repertoire of education for everybody (inclusive) consisting of body experiences: our body not only has a function of sensory and executive mediation between the brain and the external world, but it is the main device through which, by realizing experiences, we develop learning and produce knowledge.

In this scenario, the paradigm of the Embodied Cognitive Science (ECS) (Caruana & Borghi, 2013; Gomez Paloma, 2013) emerges with power and becomes the scientific and contextual basis 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 (Gallese & Goldman, 1998; Rizzolatti & Craighero, 2004), the value of corporeality, with which the neurons make phenomenologically possible the engagement of the social intersubjectivity (Iacoboni et al., 1999, 2005; Gallese, 2009), 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 the Physical Education out of the gym room, for education with body and movement, the ordinary and inclusive didactics justify with more significance and repercussion the inclusion of neurosciences. When the importance of corporeality and emotionality in the meaningful learning, and the culture of inclusion starts to gain meaning and validity, there's always multimediality and multimodality of teaching and learning… There are questions and doubts regarding how to work constructively at school. Therefore, doubts remain whether and how to rethink an "ECS based" teaching method (Gomez Paloma & Damiani, 2015), that is, a method enhancing the body and the movement as integral parts of the educational process.

3. Educational Robotics as application of an "ECS based" teaching method for the prevention of neurodevelopmental disorders and the promotion of the integration

Recent studies have shown that much of the reading difficulties of dyslexic subjects depends on the visual sensitivity and the auditory frequencies of the magnocellular system. The impairment of the magnocellular system impacts also the cerebellum, and then movements and balance. Some research seems to indicate that the degree of wobble is correlated with the degree of dyslexia (Stein, 2001), showing how our cognitive abilities are closely related to the movement abilities. So the first insights of Rod Nicholson and Angela Fawcett are confirmed (1995; 2000): the awareness of one's own body and of the movement enhances cognitive ability, through the relationship between auditory-visual movement aspects and cognitive skills in general (reading skills in the specific case of dyslexia).

In view of all this, there is an urgent need for rethinking didactics according to new integrated perspectives, which are scientifically based and pedagogically oriented towards human, social and inclusive values. The "Embodied Cognitive Science (ECS) based teaching method" (Gomez Paloma & Damiani, 2015), being based on pedagogical-didactic principles consistent with the pattern of the ECS, enhances perceptions, emotions, body and movement as integral parts of the cognitive-intellectuals processes (personal) and the educational process (interpersonal and environmental). In particular, in this article, we propose an ECS teaching method approach, according to the constructionist pattern that takes advantage of the Educational Robotics. We believe that the artifact-cognitive robot, used in a constructivist learning and experiential environment, allows to widen the main evolutionary and educational elements and processes of the ECS pattern. In other words, by manipulating and interacting with the robot body through their own body and that of their companions, students can actively contribute to the knowledge-building processes through an immersive and generative learning experience, characterized by: body-kinesthetic-sensory and emphatic experience, artistic and aesthetic experience, involvement of bodies and minds, emotional-motivational involvement, cooperation and exchange, research and involvement, creativity and reflection, solitude and community.

Particularly, the play and the work with robots are focused on intersubjective and intercorporeity dimensions of learning and development. "Before and below mind reading is intercorporeity as the main source of knowledge we directly gather about others" (Gallese, 2007). Embodied simulation model of Gallese challenge "the notion that the sole account of interpersonal understanding consists in explicitly attributing to others propositional attitudes like beliefs and desires, mapped as symbolic representations. A direct form of understanding of others from within, as it were – intentional attunement – is achieved by the activation of neural systems underpinning what we and others do and feel. Parallel to the detached third-person sensory description of the observed social stimuli, internal nonlinguistic "representations" of the body-states associated with actions, emotions, and sensations are evoked in the observer, as if he or she were performing a similar action or experiencing a similar emotion or sensation" (Gallese, 2009, p. 524).

The experience with robots – having a human or animal (pet) form – benefits from the advantages of teaching with technologies, but it amplifies its effects and creates new paradigms. Indeed, the mind-computer metaphor underlies the common teaching methods and theories in a rather simplistic sense, according to the idea that human mind works like a computer and that learning is a matter of generalization, principles, rules and logical calculations. Computers work according to rules telling how to manipulate symbols and the latter have no meaning beyond the manipulations that the computer performs on them (Gee, 2007, p. 71). An additional problem of a simplicistic mind-computer association is that the computer is a brain with no body; on the contrary, the robot is a technology with a brain and a body endowed with movement, sensoriality and physicality (Grimaldi, p. 119). This represents an innovative and valuable element, essential to the achievement of a teaching activity through "ECS based" technologies, that is, considering the evolutionary and educational role of corporeality and the intersubjective physical-motor experience. We believe that this factor can justify the attention to Educational Robotics as an innovative and inclusive educational strategy, although there are more factors of interest consistent with the frameworks of ECS and neurosciences synthetically outlined in the previous paragraph, which can enhance every person's learning processes. Among these, for example, there's the "profound" attribution of value and the strategic planning based on forecasts, favorable conditions for learning according to neurosciences (Damasio, 1994; 2010), which constitute "almost regular" conditions of the experience with Robotics. Moreover, with reference to the essential characteristics of the approach with robots, and in the light of the ECS pattern and the studies on learning and learning disabilities, we believe that teaching with robots fosters the development of non-verbal and visuospatial skills and the acquisition of concepts of relationship in all students, thus constituting an aid (a strengthening) for students with learning difficulties or suspected risk of Specific Learning Disorder (SLD) or Non-Verbal disorder and ADHD. In fact, the visuomotor dimension, which is characteristic of the mirror neurons activity, is usefully stimulated by the programming – the eye-hand and visual-spatial coordination action that the activity with the robot stimulates. More generally, literature recognizes how, through the action/relationship between students and robots, the development of cognitive and emotional-relational skills is stimulated. For what concerns its structural and application characteristics, the teaching-learning process through Robotics is therefore consistent with the multidimensionality of the learning processes. The approach with robots includes different dimensions that the traditional teaching activity ignores: physicality and sensoriality; creativity and playfulness; emotion and motivation; prosociality and collaboration. In addition, the emotional-relational value and the relational experience with the robot, investigated by the recently born field of Affective Computing (Picard, 1988), considers Robotics as a new and exciting frontier for the work of the psychologist (Caci, D'Amico, Cardaci, 2004), with strong potential in the area of the rehabilitation of persons with different forms of cognitive disabilities and affective problems. Cognitive aspects as thought, attention and memory are stimulated in an effective, intensive and expanded way; as Caci outlines, the narrative thought emerges in all its meaningfulness (Smorti, 1994), which leads to consider the artifact not as a simple stimulus-response robot, but as a real "living" organism, with its own "history", "personality", "emotions" and "mental states" (Caci, 2004; Cardaci, Caci, D'Amico, 2003). The use of robots, being a material and mobile artifact with anthropomorphic or animal features, sets the relationship between student – teacher – technology as an "enriched" relationship than the one with other technologies as it has corporeal, emotional and empathetic aspects, as well as mental and cultural aspects. In this sense, thinking the robot turns into thinking with the robot. The use of robots seems to be useful both for the strengthening of the specific visual-spatial skills, also through the exercise of the abilities of vision, perception, discrimination of the visual-constructive forms and abilities, and for the development of the key aspects of the executive functions: attention, working memory, self-regulation, planning. Robotics can be "fully used" early with educational purposes. Although literature does not identify "certain" predictive factors, researches on the effectiveness of the evidence-based treatments show the need for the extra-school or, in any way, early treatment of the conditions of risk or comorbidities. In pre-school, it's not appropriate to invest in the early learning of reading and writing, but in the acquisition of the preconditions, in the praxis and the visual-spatial skills. Many authors emphasize the importance of working "on the basis of critical areas" (visuospatial and nonverbal areas are considered as such) and class-groups; intervening individually during pre-school or during the first year of primary school does not seem appropriate (Penge, 2013).

Robotics lends itself to group activities and works on the basis of fields or general areas. The relationship between perception and attention, which can be critical in some children, is supported by experiences fostering the interconnection and exchange between the two processes through a continuous transition: from perception to action and from action to perception. Moving the robot and moving with the robot strengthens this interconnection and can ease the mental representation of the space and the time of the actions, thus the learning of spatial and temporal concepts. Highlighting the relationship between the visual-spatial and motor and praxis skills is consistent with the activities of children's "controlled" movement and manipulation with Robots. It seems we're able to say that the body of the robot can also constitute an "additional / accessory" body or a body supporting the child's body, able to perform the functions of guidance and coordination of movements that he\she has planned. We believe that the opportunity to make the results of using space-time concepts and the planned movement sequences more visible (by observing the acting robot) will facilitate the child's functions of control, self-monitoring and metacognition, which are essential for the possibility to achieve an "authentic and significant" learning.

The notion of simulation (Gallese, 2005b; 2009) has assumed a central role in the theories of the Embodied Cognition; in particular it's made reference to the motor simulation during the observation of objects or people performing an action, and the comprehension of a language. The learning experience with the robot is characterized as a relational experience that is essentially different from that with a computer or another electronic device. The relationship child-computer is basically a relationship with a symbolic system, with a mind without a body; on the contrary, the relationship child-robot is the relationship of a person with a mind and a body in movement with another subject with a mind and a body in movement. It's a most complete and interesting relationship, characterized by reciprocity and physicality. In a learning environment built up through Robotics, the relational configurations get more complicated: in the experience with the robot – knowledge mediator, relationships between student-teacher-artifact, student-knowledge-artifact and student-fellows-artifact-knowledge are established. As stated by Baccaglini Frank (2013), it's paid less attention to the direct student-direct relationship, which is less significant and stimulating for many students.

An additional sphere of application/implications of the ECS teaching method through Robotics refers to the prevention of the socio-relational difficulties of adolescents. Researches on adolescents have revealed a sort of "relational incompetence" essentially due to the experiences characterized by almost totally virtual or strongly mediated relationships, in which the body is absent. Adolescents' relationships are distinguished by continuity and pervasiveness, but they're not very deep. Young people are always connected, but they're often disconnected from their own bodies and from their own global person and that of others (Pietropolli Charmet, 2013). In fact, the intensity and amount of virtual relationships have compensated for the absence of corporeal relationships; the problem is that it is mostly about relationships with no shame, modesty and empathy, characteristics of the relationships that don't involve a body. As already mentioned, we believe that the relationship with the robot body can foster the construction of the (own and others ') body representation, and the care of the body and the person, in children and younger people .

From a more properly technology- IT perspective, the task of programming the robot movements refers to the logical principles of programming through codes-languages enhancing the expressive, narrative and semantic skills. The programming, understood as a problem-solving activity (Teolis, 2015), involves the expression and language use skill. The solution of the problems is basically linguistic; to solve this problem, we need to think and talk about the problem, assign it a name, search for signs of communication and some rules, both through the inner dialogue and through the comparison with others. The extension of linguistic and expressive areas through the use of the body and of the robot body (metaphorical and non-verbal language) fosters the extension of the problem solving skills.

With regards to the value of integration, considered as another leading principle in our framework of values beyond that of the person's global development, the stimulation of cognitive and emotional-relational skills fosters the learning-development process of all students and increases their freedom/possibility of participation and co-participation through a process of general skills development.

In summary, the intervention of basic skills enhancement, through the use of Educational Robotics for the whole class, has three kinds of advantages:

1. evolutionary advantages for the development of the cognitive processes in a broader sense, i.e. including emotional and corporeal dimensions, in addition to those cognitive in the strict sense of the word: perception, attention, thought, memory;
2. educational advantages for the person's education, in his\her bio-psycho-social entirety, in the interaction with the environment;
3. social advantages, for the building of more inclusive learning environments and societies based on the values of fairness and co-participation.

Last but not least, from the teachers and didactic programming perspective, the educational intervention through the use of Educational Robotics can be considered as an example of didactic (and evaluative) activity by skills, as it promotes the application of knowledge and skills in "authentic" tasks of increasing complexity (aiming at the competence), within specific contexts. The robot "makes doing things" with concepts/knowledge and spatial-temporal, linguistic, cognitive, emotional, physical and relational skills, in order to achieve a complex task all together, involving teachers and classmates. Moreover, the knowledge gained through the use of Robotics, different levels of knowledge and skills (for example, from the topological notions to the ability to plan routes and make sure they are correct) must then be used in other tasks and contexts (thus, it must be transferred). Knowledge is mobilised in the transition from the experience with Robotics (concrete\ laboratory-based) to the assignments at school (abstract and formalised) and its use in life contexts (concrete-authentic).

In general, Educational Robotics represents a method for the laboratory-based didactics based on the "learning by doing": according to Papert, it's easier, and almost natural, to learn with a robot.

References

Ackermann E. (2001). Constructivisme et constructionnisme: quelle difference? In Actes du colloque *Constructivismes: usageset perspectives en education* (vol. 1, pp. 85-97). 4-8 Settembre 2000, Genève, Suisse.

Acone G. (2005). *L'orizzonte teorico della pedagogia contemporanea. Fondamenti e prospettive.* Salern: Edisud.

Alvarez L., Rios A.M., Adams K., Encarnação P., Cook A.M. (2013). From infancy to early childhood: the role of augmentative manipulation robotic tools in Cognitive and Social Development for Children with Motor Disabilities. In J.L Pons, D. Torricelli, M. Pajaro (Eds.), *Converging Clinical and Engineering Research on Neurorehabilitation Biosystems & Biorobotics* (pp. 905-909). Retrieved from http://link.springer.com/content/pdf/10.-1007%2F978-3-642- 34546-3 _147.pdf

Baccaglini-Frank A. (2013), *How might multi-touch technology be a powerful aid for preschoolers' development of numerical abilities?* Chapters of selected papers in "International Congress of Educational Sciences and Development", Santander.

Beauchamp MS., Lee KE., Argall BD., Martin A. (2004a). Integration of auditory and visual information about objects in superior temporal sulcus. *Neuron*, 41, 809-823. [PubMed].

Beauchamp MS., Argall BD., Bodurka J., Duyn JH., Martin A. (2004b). Unraveling multisensory integration: patchy organization within human STS multisensory cortex. *Nature Neuroscience,* 7, 1190-1192. [PubMed]

Besio S. (2005). *Tecnologie assistive per la disabilità*. Lecce: Pensa MultiMedia.

Besio S. (ed.) (2009). *Methodological framework to set up educational and therapy sessions with robotic technology: the IROMEC proposal*. Trento: UNI Service.

Besio S. (2010). *Giochi e giocattoli per il bambino con disabilità motoria*. Milano: Unicopli.

Burns J. (2012). *Robots in the classroom help autistic children learn.* BBC News education reporter, 8 November 2012, Education & Family, http://www.bbc.com/news/education-20252593.

Caci B. (2004). *Laboratorio di robotica: una palestra per la mente.* Proceeding del Congresso Nazionale dell'Associazione Italiana di Psicologia (AIP), Sezione di Psicologia Sperimentale, Roma.

Caci B., D'Amico A., Cardaci M. (2004). New frontiers for psycology and education: robotics. *Pychological reports*, 94 (3c), 1372-1374.

Caci B., D'Amico A., Cardaci M. (2007). *La robotica educativa come strumento di apprendimento e creatività* (http://formare.erickson.it/wordpress/it/2007/la-robotica-educativa-come-strumento-di-apprendimento-e-creativita/).

Cardaci M., Caci B., D'Amico A. (2003), *Giocare e Pensare con i Robot. Strategie di problem-solving a confronto.* Proceeding Giornata AIP sul Pensiero. Firenze, 12 Giugno.

Caruana F., Borghi A.M. (2013). Embodied Cognition: una nuova psicologia. *Giornale Italiano di Psicologia.* Bologna: Il Mulino.

Contini M., Fabbri M., Manuzzi P. (2006). *Non di solo cervello. Educare alle connessioni mente-corpo-significati-contesti*. Milano: Raffaello Cortina.

Damasio A. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain.* Putnam.

Damasio A. (1999). *The Feeling of What Happens: Body and Emotion in the Making of Consciousness.* Harcourt.

Damasio A. (2010). *Self Comes to Mind: Constructing the Conscious Brain.* Pantheon.

Damiani P., Grimaldi R., Palmieri S. (2013). *Robotica educativa e aspetti non verbali nei Disturbi Specifici di Apprendimento.* Pisa: Didamatica-Aica-Università di Pisa.

Dapretto M., Davies M.S., Pfeifer J.H., Scott A.A., Sigman M., Bookheimer S.Y., Iacoboni M. (2006). Understanding emotions in others: Mirror neuron dysfunction in children with autism spectrum disorders. *Nature Neuroscience*, 9, 28-30.

Dautenhahn K. (1999). Robots as social actor. Aurora and the case of autism. *Proc. International, Cognitive, Technology, Conf.* 359-374.

Dautenhahn K., Werry I. (2004). *Towards interactive robots in autism therapy: background, motivation and challenges. Pragmatics and Cognition*, 12, 1, 1-35.

Duffy T. M., Jonassen D. (Eds.). (1992). *Constructivism and the technology of instruction: A conversation*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Edelman G. M. (1993). *Bright Air, Brilliant Fire: On the Matter of the Mind.* Basic Books.

Edelman G.M. (2006). *Second Nature: Brain Science and Human Knowledge.* Yale University Press.

Ferrari E., Robins B., Dautenhahn K. (2009). *Therapeutic and educational objectives in Robot Assisted Play for children with autism.* Proceedings: "The 18th IEEE International Symposium on Robot and Human Interactive Communication" Toyama, Japan, Sept. 27-Oct. 2, 2009.

Ferri P. (2013). *La scuola 2.0. Verso una didattica aumentata dalle tecnologie.* Parma: Spaggiari.

Gallese V. (2005b). Embodied simulation: from neurons to phenomenal experience. *Phenomenology and the Cognitive Sciences*, 4, 23-48.

Gallese V. (2006). Corpo vivo, simulazione incarnate e intersoggettività, in Neurofenomenologia. Le scienze della mente e le sfide dell'esperienza cosciente. In M. Cappuccio (a cura di), *Neurofenomenologia: le scienze della mente e la sfida dell'esperienza cosciente.* Milano: Mondadori.

Gallese V. (2007). Dai neuroni specchio alla consonanza intenzionale. Meccanismi neurofisiologici dell'intersoggettività. *Rivista di Psicoanalisi*, 2007, LIII.

Gallese V. (2009). Mirror neurons, embodied simulation, and the neural basis of social identification. *Psychonalytic Dialogues*, 19, 519-536.

Gallese V. (2012). Aby Warburg and the dialogue among aesthetics, biology and physiology. *Ph*, 2, 48-62.

Gallese V., Goldman A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Sciences*, 12, 493-501.

Gamelli I. (2011). *Pedagogia del corpo.* Milano: Raffaello Cortina.

Gee P. (2007). *What Video Games Have to Teach Us About Learning and Literacy.* Palgrave Macmillan.

Gee P. (2010). *New digital media and learning, a san emerging area and worked examples as one way forward.* Cambridge: Mit press.

Gilbert J. (2012). The Pedagogy of the Body: Affect and collective individuation in the classroom and on the dance floor. *Educational Philosophy and Theory*, 1-12 Routledge.

Gomez Paloma F. (2004). *Corporeità ed emozioni. Una didattica psicomotoria del saper essere*. Napoli: Guida

Gomez Paloma, F. (2009). *Corporeità, didattica e apprendimento. Le nuove neuroscienze dell'educazione.* Salerno: Edisud.

Gomez Paloma F. (2013). *Embodied Cognitive Science: Atti incarnati della didattica.* Roma: Nuova Cultura.

Gomez Paloma F., Damiani P. (2015). *Cognizione corporea, competenze integrate e formazione dei docenti. I tre volti dell'Embodied Cognitive Science per una scuola inclusiva.* Trento: Erickson.

Grimaldi R. (2015) (a cura di). *A scuola con i Robot.* Bologna: Il Mulino.

Howard-Jones P.A. (2009). *Neuroscience, learning and technology* (14-19). Becta.

Iacoboni M., Woods R.P., Brass M., Bekkering H., Mazziotta J.C., Rizzolatti G. (1999). Cortical mechanisms of human imitation. *Science*, 286, 2526-8.

Iacoboni M., Molnar-Szakacs I., Gallese V., Buccino G., Mazziotta J.C., Rizzolatti G. (2005). Grasping the intentions of others with one's own mirror neuron system. *PLoS biology*, 3, 79.

Jeannerod M. (2007). *Motor cognition. What actions tell to the self.* Oxford: University Press.
Jonassen D. H. (1997). Instructional design model for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology, Research and Development,* 45(1), 65-94.
Jonassen D.H., Beissner K., Yacci M. (Eds.) (1993). *Structural knowledge. Techniques for representing, conveying, and acquiring structural knowledge*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Jonassen D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory*, (Volume II, pp. 215-239).
Jonassen D. H., Campbell J. P., Davidson M. E. (1994). Learning with media: Restructuring the de-bate. *Educational Technology, Research and Development*, 42(2), 31-39.
Jonassen D.H. et al. (1995). Supporting Communities of learning with technology. A vision for integrating technology with learning in schools. *Educational Technology*, 35, 4, 60-63.
Jonassen D. H., Peck K., Wilson B. G. (1998). *Learning WITH technology: A constructivist perspective.* Columbus, OH: Merrill/Prentice-Hall.
Leroux P. (1999). Educational Robotics. *International Journal of Artificial Intelligence in Education*, 10, 1080-1089.
Marconato G., Litturi P. (2005). Conversazione con David Jonassen. *Sistemi e Impresa*, 9, 15.
Nicolson R.I., Fawcett A.J. (1995). Dyslexia is more than a phonological disability. *Dyslexia*, 1, 19-36.
Nicolson R.I., Fawcett A.J. (2000). Long-term learning in dyslexic children. *European Journal of Cognitive Psychology*, 12, 357-393.
Papert S. (1972). *Learn Think to Children.* UCLA (University of California Los Angeles).
Papert S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York: Basic Books.
Papert S. (1993). *The children's machine*. New York: Basic Books.
Pavone M. (2015). *Scuola e bisogni educativi speciali*. Milano: Mondadori Università.
Penge R. (2013). Atti del convegno "*Imparare questo è il problema*", San Marino, 21-22 settembre, 2013.
Pennazio V. (2015). *Didattica, gioco e ambienti tecnologici inclusivi*. Milano: Franco Angeli.
Pennazio, V. (2015). Disabilità, gioco e robotica nella scuola dell'infanzia. *TD Tecnologie Didattiche*, 23(3), 155-163.
Pennington B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition,* 101, 385-413 10.1016/j.cognition.2006.04.008
Perkins D. N. (1991a). Technology meets constructivism: Do they make a marriage? *Educational Technology*, 31 (5), 19-23.
Piaget J., Inhelder B. (1967). *The Child's Conception of Space. See especially "Systems of Reference and Horizontal-Vertical Coordinates*"., New York: W. W. Norton &Co.
Picard R. W. (1988). *Affective computing.* Cambridge MA: MT Press.
Pietropolli Charmet G. (2013). *La paura di essere brutti. Gli adolescenti e il corpo.* Milano: Raffaello Cortina.
Rivoltella P. C. (2013). *Neurodidattica. Insegnare al cervello che apprende.* Milano: Raffaello Cortina.
Rizzolatti G., Craighero L. (2004). The Mirror-Neuron System. *Annual Rev. Neurosci.,* 27 169-192.
Rizzolatti G., Sinigaglia C. (2006). *So quel che fai. Il cervello che agisce e i neuroni a specchio.* Milano: Raffaello Cortina.
Savery J., Duffy T. M. (1996). Problem based learning: An instructional model and its constructivist Framework. In B. G. Wilson (Ed.), *Designing constructivist learning environments* (pp. 135-148). Englewood Chffs, NJ: Educational Technology Publications.
Scassellati B., Admoni H., Matarić M. (2012). Robots for Use in Autism Research. *Annual Review of Biomedical Engineering*, 14, 275-294.
Skipper J. I., Nusbaum H. C., Small S. L. (2005). Listening to Talking Faces: Motor Cortical Activation During Speech Perception. *Neuroimage*, 25, 1, 76-89.

Smorti A. (1998). *Il pensiero narrativo.* Firenze: Giunti.
Stein J. (2001). The magnocellular theory of developmental dyslexia. *Dyslexia*, 7, 1, 12-36.
Teolis A. (2015). Atti dei corsi di formazione MIUR per le "*Olimpiadi di Problem Solving*", Firenze, 30 gennaio 2015.
Uithol S., Gallese V. (2015). *The role of the body in social cognition.* Wiley Interdisciplinary Reviews: Cognitive Science, John Wiley & Sons Ltd, A Wiley Company.
van Duijvenvoorde A. C. K., Zanolie K., Rombouts S., Raijmakers M. E. J., Crone E. A. (2008). Evaluating the Negative or Valuing the Positive? Neural Mechanisms Supporting Feedback-Based Learning across Development. *Journal of Neuroscience*, 28, 38, 9495-503, http://www.olimpiadiproblemsolving.com/documenti/OPS-firenze-gennaio2015-_2.pdf
Willson B. (1996). *Constructivist learning environments: Case studies in instructional design.* New Jersey: Educational Technology Publications.