Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva / Italian Journal of Health Education, Sports and Inclusive Didactics - Anno 5 n. 2 - ISSN 2532-3296 ISBN 978-88-6022-411-8 - aprile - giugno 2021 - CC BY-NC-ND 3.0 IT - https://doi.org/10.32043/gsd.v5i2.377

PHYSICAL EDUCATION BETWEEN NEUROSCIENCE AND COMPLEXITY: THE SYSTEMIC PERSPECTIVE APPLIED TO INCLUSIVE DIDACTICS

EDUCAZIONE FISICA TRA NEUROSCIENZE E COMPLESSITÀ: LA PROSPETTIVA SISTEMICA APPLICATA ALLA DIDATTICA INCLUSIVA

Cristiana D'Anna
University of Salerno
cdanna@unisa.it

Daniele Albano
University of Salerno
dalbano@unisa.it

Benedetta Romano
University of Salerno
b.romano4@studenti.unisa.it

Rodolfo Vastola
University of Salerno
rvastola@unisa.it

Abstract

National and international documents (UNESCO, 2017; MIUR, 2012; 2020) promote the improvement of the quality of teaching-learning processes, underlining the need to design flexibility learning environments able to respond to multiple educational needs. Physical education, like other disciplines, is involved in the process of *full inclusion* process with the awareness that in order to face to the complexity of the system (group-class), which in turn consists of a network of interconnected complex adaptive systems (pupils) – which acting and interacting with each other - a systemic approach is needed, able to of implementation of open and flexible teaching practices (Sibilio, 2014).
This study aims to outline, in the light of recent neuroscientific researches (Mandolesi, 2012) and studies on complexity (Clark & Crossland, 1985; Davids & Araùjo, 2010), some basic principles to design inclusive learning environments in physical education.
The systemic perspective, starting from the awareness that there is no boundary between what is physical and what is cognitive and that the environment that surrounds us is able to modulate our brain circuits, opens up new scenarios on which to reflect in order to face the 'unpredictability, emergency and self-organization, which act in and on the teaching-learning process, determining its effectiveness.

I documenti nazionali e internazionali (UNESCO, 2015; MIUR, 2012; 2015) promuovono il miglioramento della qualità dei processi d'insegnamento-apprendimento, sottolineando l'esigenza di una flessibilità progettuale che sappia rispondere efficacemente ai molteplici bisogni formativi. Anche l'educazione fisica è coinvolta nel processo di *full inclusion* con la consapevolezza che per far fronte alla complessità del sistema (gruppo- classe), a sua volta costituito da una rete di sistemi adattivi complessi (allievi) - agenti e interagenti tra loro - è necessario un approccio sistemico capace di implementare pratiche didattiche aperte e imprevedibili (Sibilio, 2014).
Il presente contributo ha l'obiettivo di declinare, alla luce delle recenti scoperte neuroscientifiche (Mandolesi, 2012) e degli studi sulla complessità (Clark & Crossland, 1985; Davids & Araùjo, 2010), alcuni principi basilari per la progettazione di ambienti di apprendimento inclusivi in educazione fisica.
La prospettiva sistemica, partendo dalla consapevolezza che non esiste un confine tra ciò che è motorio e ciò che è cognitivo e che l'ambiente che ci circonda è in grado di modulare i nostri circuiti cerebrali, apre nuovi scenari sui quali riflettere per poter affrontare l'*imprevedibilità*, l'*emergenza* e l'*auto-organizzazione*, che agiscono nel e sul processo d'insegnamento-apprendimento determinandone l'efficacia.

Keywords
Complexity, Inclusive didactics, Learning environment, Neuroscience, Physical education
Complessità, Didattica inclusiva, Ambienti di apprendimento, Neuroscienze, Educazione fisica

Introduction

In recent decades, inclusive education has been the subject of great attention at national and international level, both from the political world and from pedagogical and didactic research. The United Nations Organization has highlighted its centrality, making the inclusion a protagonist of Objective 4 of the 2030 Agenda for Sustainable Development, assigning it a fundamental role for the improvement of the quality of life. The goal, invests on training considering knowledge and skills the necessary tools that «provide a quality education, fair and inclusive and learning opportunities for all» (UNESCO, 2017).

The change in the way of *making school* has seen the overcoming of the simple integration of pupils/ students in the classrooms in favour of a new organization and planning of teaching aimed at a real inclusion of everyone and everyone, that through measures of "adaptation" of the programmatic plans, of diversified organization of the methodologies and of the system of evaluation of the learnings, promotes the concept of "personalization" of these that is in line with the more current conception of "inclusive didactics" (D'Anna, 2020). The *focus* is no longer on the individual student and its difficulties to recover, but is on the context and how to improve it, designing effective and adequate "facilitators" and eliminating or reducing the "barriers" to participation and learning (WHO, 2001; 2007).

It is a real paradigmatic change that "observes" and "grasps" the differences according to a different perspective oriented to the deep understanding of the strengths and weaknesses of the students. The logic of *full inclusion* invites teachers to take the concept of difference as a guiding principle for inclusive teaching action, recognizing the importance of a systemic and complex approach that solicits the responsibility of teachers (Di Gennaro et al., 2018). The practice of physical education (PE), as already stated by the *International Charter for the EF, Physical Activity and Sport* (1978) is a fundamental right for all strongly reaffirmed in the 2015 version also through the introduction of universal principles: gender equality, not-discrimination and social inclusion in and through sport. The most recent national and international documents internazionali (MIUR, 2012; 2018, Bangsbo et al., 2016; WHO, 2018) highlight the benefits of physical education and sport, underlining its potential, also in the light of recent reports on the quality of inclusive processes, not without critical points (UNESCO, 2017; 2019) and the current pandemic situation (UNESCO, 2021).

The Italian school system, in recent decades, has put in the foreground the inclusive teaching through a succession of regulatory interventions, from the different Guidelines (2009; 2010; 2011) to the directives and ministerial circulars for pupils with Special Educational Needs (MIUR, 2012; 2013), from Law 170/2015 to the most recent legislative decrees (2017; 2019; 2020), confirming a strong commitment in this direction.

The improvement of teaching-learning processes, requires the need for a design flexibility that can effectively respond to the multiple training needs through a new organization and planning of teaching able to reduce all forms of exclusion (Booth, 2011, p. 304) promoting inclusive quality processes (Booth & Ainscow, 2008). The EF is also involved in the process of *full inclusion* with the awareness that to cope with the *complexity of the system* (group-class), in turn consisting of a network of complex adaptive systems (students) - agents and interacting with each other - it is necessary to implement open and unpredictable teaching practices (Sibilio, 2014), able to respond to different training needs.

The learning experiences offered to pupils and students during EF lessons, must be adequately designed to guide them in the development of psychomotor skills and abilities, in the cognitive understanding and in the acquisition of the social and emotional abilities useful to the construction of a better quality of life, in the full respect and valorization of the differences and the peculiarities that distinguish them (Mclennan & Thompson, 2015).

In the light of recent neuroscientific findings (Mandolesi, 2012) and studies on complexity (Clark, 1997; Davids & Araùjo, 2010; Davis & Sumara, 2012), this paper focuses on the design of learning environments, assuming a systemic approach to Inclusive Teaching in EF (SAIT-inEF), in which the non-linearity of teaching-learning processes (Chow et al. 2016; Correia et al., 2019) becomes the point of convergence between neuroscience and complexity.

1. Neuroscience and complexity: motor system as a *complex cognitive system*

Until fifty years ago there was a clear separation between the associative areas of the cortex designated for cognitive processes and the motor areas, excluded from these processes and purely dedicated to the elaboration of motor aspects.

Recently behavioural, neurophysiological and neuroanatomical studies have questioned this traditional model of cognition, re-evaluating the role of the motor system, which assumes a determining function in this regard. 'The motor cortex as a whole comprises a primary motor cortex, which gives final command for movements, and a premotor cortex, or primary cortex of higher order, that is instead involved in the programming that is upstream of the final execution of the movement» (Fogassi, 2019). These findings confirm the centrality of the motor system, involved not only in the execution of movements, but also fully involved in the planning of finalized actions. Some movements, even simple, could not be always activated by the cerebral cortex; they can instead be directly controlled by the spinal cord or be mediated by cortical and subcortical areas not motor (Mandolesi, 2012). The connections between the different motor areas and not, highlighted by the most recent neuroscientific studies, show that the motor system is also a *complex cognitive system*. This highlights the overcoming of the traditional model of cognition with a revaluation of the motor system, no longer seen as a simple performer, but the main protagonist in the programming and planning of motor acts and finalized actions (Lakoff & Johnson 1999; Berthoz, 2011; Berthoz & Petit, 2006; Rizzolatti, & Senigallia, 2006; Gallese et al. 1996). In this sense cognition is no longer considered the representation of a predetermined world by a predetermined mind, but rather becomes *enactment*, that is, the production of a world and a mind on the basis of the lived experiences and actions that a being performs in the world (Varela et al., 1991). Knowledge, therefore, is seen as an active process, rooted in the body and in the biological dimension (Varela et. al 1992; Lakoff & Johnson 1999).

In the light of the briefly described scientific evidence, research in the field of education has reassessed the biological dimension in the relationship between teaching and learning, increasingly strengthening the binomial pedagogy-neuroscience tracing new trajectories of studies and research with the aim of overcoming methodological reductionism, anchored to an idea of reality modelled by abstract underlying principles that can be interpreted through physical and mathematical formulas, that focuses attention on the main parameters, considered to have a greater impact than the minor ones and breaks down the problems into simpler parts losing sight of the global nature of the system, leaving out the relationships between the different parts that make up the system itself.

The overcoming of this perspective has allowed contemporary scholars to take up the concept of complexity, starting from the assumption that "the whole is greater than the sum of the parts" (Aristotle). An approach that inevitably clashes with reductionism, overturning the vision of reality that is characterized, therefore, as complex. «There is complexity when the different components that make up a whole are inseparable [...] and when there is an interdependent, interactive and inter-retroactive fabric between the parts and the whole and between the whole and the parts» (Morin, 1999, p. 6). Overcoming the idea of stable equilibrium states, characterized by uniformity of configuration and regularity of the arrangements, complex systems are presented as dynamic and unstable, in constant and progressive adaptation and readjustment through a changeable passage from one configuration to another, so as to legitimize the consideration that «to the monotonous and 'stationary' universe of the simple and homeostatic systems has alternated an 'uncertain' universe» (Morin, 1977). The parameters that characterize the paradigm of complexity refer to nonlinearity, multidimensionality, discontinuity, contradiction and randomness of processes.

The paradigm of complexity, on the same wave of neuroscience, invites to take a systemic perspective, starting from the awareness that there is no boundary between what is physical and what is cognitive and that the environment around us is able to modulate our brain circuits.

The reassessment of the biological dimension of learning resulting from the scientific evidence of neuroscience, the resulting new pedagogical guidelines, the complexity paradigm and the current regulatory frameworks promote the study and research of innovative processes in the educational field. Remarkable in Italy are the didactic guidelines in this regard from *Bio-education* (Fraunfelder, 1994) to *Semplessità* (Sibilio, 2014), from *Didattica Enattiva* (Rossi, 2011) to *Neurodidattica* (Rivoltella, 2012) to the most recent *Didattica Embodied* (Gomez Paloma, 2017) which, with the aim of improving the quality of teaching-learning processes, take up the challenge posed by neuroscience and complexity.

In teaching PE field, the international scientific literature responds to this challenge through the implementation of a series of approaches that in ecological-dynamic and systemic perspective, from *coordination dynamics* (Kelso, 1984; 1995) to *Ecological Approach* (Gibson, 1979); from *Constraint Led-Approach* (Newell, 1986; Davids et al., 2008; Renshaw et al., 2016) to *Non-linear Pedagogy* (Chow, 2007; 2013) propose new innovative scenarios in the design and development of learning environments. These are studies which in recent years have focused research more on the technical performance; in fact, the scientific literature of these approaches in the field of PE in the school context is less substantial and even less so in an inclusive perspective.

2. Principles of Dynamical Systems Theory as a framework to reflect in didactics

The teaching-learning process in general, but particularly in physical activities is characterized as an embodied process, situated, distributed, in which the different behaviours emerge ad adaptive responses of our neurobiological system to a series of interacting constraints. At the basis of this statement is the awareness that our every behaviour is a phenomenon emerging from a bi-directional organism-environment synergy (Beek & Meijer, 1998, p. 106). In the domain of biological system characterized by such processes, what is crucial is not the regularity or constants, but the starting conditions, the organizing principles, the attracting states, the emergence of forms, assume greater importance, the unpredictability and adaptability of configurations and what emerges.

Dynamic Systems Theory is able to explain through an integrated approach aspects of learning, cognitive development and pedagogy; This is a paradigm shift that implies acceptance of chaos and complexity as it happens in multiple theoretical fields such as physics, biology, chemistry, engineering, ecology and psychology (Capra, 1996; Gleick, 1987; Thelen & Smith, 1994).

The system indicates an assembly of interacting components "whose properties derive from relations between three parts of it" (Capra, 1996, p. 27); this system is dynamic because it is changeable, synergistic, with an apparently random order.

A first element that distinguishes dynamic systems is self-organization. Students and teachers are individuals made up of different systems: biological, affective and cognitive. A view of students as complex adaptive dynamic systems emphasizes the individuality and complexity of each and every student.

Each dynamic system, in addition to being fluid and integrative, has a kind of state space, which is an abstract construct that explains how all the different and multiple emerging behaviours, are "open" to a system and "constrained" the degree of freedom available to the different components of the system itself (Thelen & Smith, 1994).

The basic teaching principle that teachers should always keep in mind is to consider each student peculiar in their own state space and in the different and possible behaviours that determine and enhance the differences between students even in the answers in terms of self-organization of its state.

Self-organization emerges from the confluence of components and variables within the system. For self-organization to occur, the system must be complex and open to changes in the environment (Thelen & Smith, 1994).

The mechanism of learning is a very complex phenomenon in which the student undergoes a series of phase changes (transitions), in which the cognitive system organizes itself by bringing out new models of understanding (Kelso, 1995). To support and facilitate these state changes, the teacher can act through control parameters that are variables external to the system that can act on it by conditioning the transition from one state to another.

Acting on the variables of the system means acting didactically on the different and interacting variables inherent in the designed learning environment.

If effective self-organization emerges it means that learning has taken place; however, there may also be the case of a noise that disturbs the system, which stimulated it to new adaptations without yet determining in the immediate the supposed learning, a self-organization that will probably happen at a later time following different times and ways. Some studies have shown that some teaching methods may have more impact than others on the perturbations of the system.

Fig. 1 graphically highlights the hypothetical effectiveness of different teaching strategies to encourage learning; cooperative learning and even more problem-solving, which are centred on the student with the teacher who assumes the role of facilitator, determine changes in the attractiveness of the student and therefore are more conducive to significant and stable learning over time (Eggen & Kauchak, 2001).

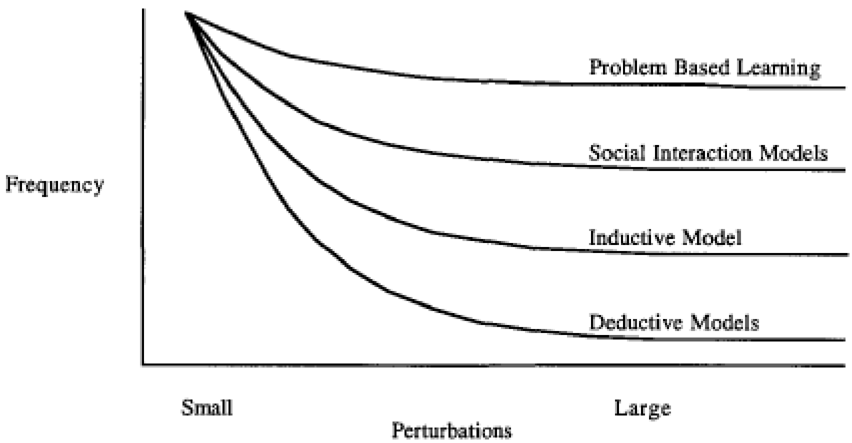

Fig. 1 The hypothetical effectiveness of different teaching strategies for facilitating learning. The more student-centred the higher the frequency of large perturbations to the system (Eggen & Kauchak, 2001)

Another aspect that distinguishes the complexity of learning environments is the non-linearity of processes, so there is no direct proportionality between input and its out-put. Pedagogically, there is not always a direct relationship between teaching and learning Teachers, from experience, know that sometimes lesson plans assumed to be effective do not occur in the implementation of teaching.

3. Systemic Approach to Inclusive Teaching in Physical Education (SAITinPE)

The quality, the intentionality, the processuallity of the educational interventions are terms that recur more and more frequently in the teaching of PS and Physical activities in formal and non-formal contexts (Colella, 2019). In fact, there is an increase in studies aimed at improving the professional skills of teachers/coaches who investigate teaching-learning processes through the analysis of the different variables in the game in the complex design and implementation of learning environments. Some of these focused on the non-linearity that characterizes the acquisition and development of motor skills (Pesce, 2002; Pesce et al., 2015; Bortoli & Robazza, 2016), placing dynamism and intrinsic complexity of learning and motor control (Davids, et al., 2008; Davids & Sumara, 2008; Renshaw et al., 2010).

Improving the quality of teaching is a key aspect for the implementation of effective educational actions and interventions aimed at the acquisition of new learning (Renshaw et al., 2010) it is necessary to respond to non-linear logic with pedagogical approaches (Chow & Atencio, 2012; Tan et al., 2012) able to grasp and enhance the individual differences between students, considering also as a priority the complex interactions that occur between individual students, the proposed tasks and the environment (Chow et al., 2011;Chow et al., 2015; Renshaw et al., 2010; Chow & Atencio, 2012). Figure 2 briefly illustrates the key elements of the Systemic Approach to Inclusive Teaching in Physical Education (SAITinPE), involved in the complex educational design management of inclusive teaching PE.

This proposed model is in a preliminary study phase, and is the subject of critical reflection and analysis before the development of field trials.

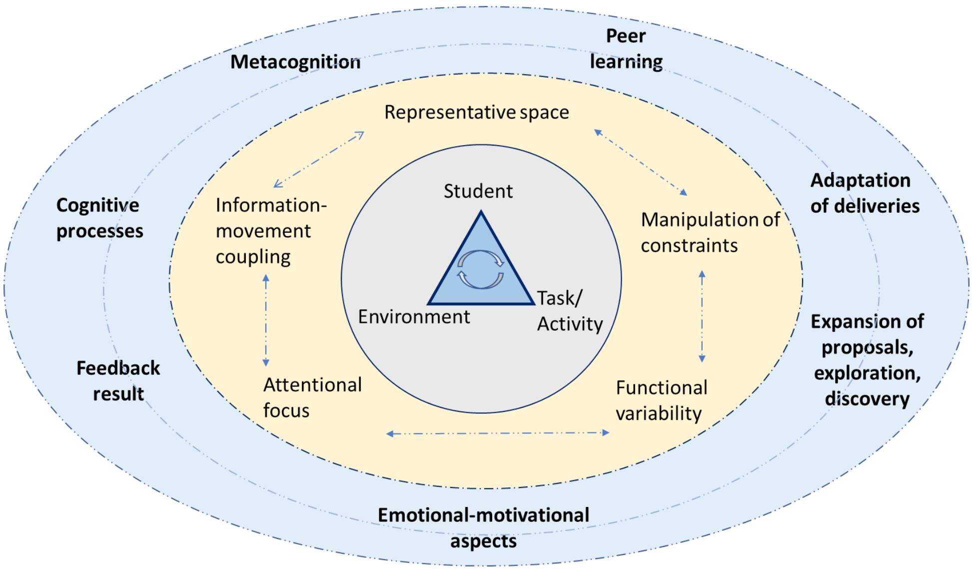

Fig. 2 (Systemic Approach to Inclusive Teaching in Physical Education -SAITinPE) (Adapted from Chow, 2013 & Zambotti et al., 2015)

It is necessary to underline that the perspective from which this model is born, shifts the focus from the technical-performance objectives to processes oriented to knowledge, skills, transversal competences, also with a view to transferring to other domains of life. In line with this perspective, in the awareness of the centrality of the approach based on the manipulation of constraints born from the ideas of Newell (1986) and Davids (2008), at the center of the model there is *individual-task-environment triad* to underline the awareness that any behavior or action directed towards a goal is the product of self-organization *emerging* from an interaction between constraints. The Constraint Led Approach (CLA), according to the theoretical framework of neuroscience and complexity, considers mind, body and environment systemically interconnected (Beer, 2003; Kelso, 1995; Port & van Gelder, 1995; Thelen & Smith, 1994; Thelen et al., 2001): one influences the other and conditions/shapes behavior/act/finalized action. A model of this type consider learning as "embodied", situated, highlighting the strong interconnection between what is cognitive and what is physical. In an integrated and at the same time systemic vision, we want to highlight that in the class group, every individual and, therefore, every *individual triad*, interconnects with other individualities; many *complex adaptive systems* interact with each other, inducing in adaptations and behavioral readjustments resulting from both these relationships and the interconnection between the different elements of didactic planning modulated and calibrated by the teacher in the situation. For this reason, the conceptual framework of SAITinPE, exemplified in fig. 2, to complete the triad, reports a double extension of the elements to be taken into consideration in the design. A first circle highlights the principles of Chow's non-linear pedagogy (2013): *representative learning design, movement- perception coupling, manipulation of constraints, functional variability, external focus of attention*; a second circle, from an inclusive perspective, in full respect and in the enhancement of differences, highlights the seven key points of inclusive education (Zambotti et al., 2015): *adapted to physical education (peer learning, adaptation of tasks, extension of proposals / exploration and discovery, emotional-motivation aspects, cognitive processes, metacognition, feedback and results.*

In Italy over the last twenty years, there have been several studies that have focused attention on some of the variables involved in the design of learning environments. By acting on the principle of manipulation and task variation, the educator/coach can create favorable conditions for meaningful learning: «creating problem situations of varying difficulty according to individual skill levels; presenting the problems to be solved and the goal to be achieved; encouraging the student to explore their skills and the opportunities of the environment, and to discover the most effective motor solutions» (Bortoli & Robazza, 2016, p. 34). The functional variability of the practice is the key to the educational method experimented in the *Joy of moving* project which starts from the development of the body in motion to reach the formation of the citizen (Pesce et al., 2015). Also interesting is the analysis of teachers' communication styles that differentiate reproduction and production styles (Mosston & Ashworth, 2008; Syrmpas et al., 2017; Colella, 2018), with significant repercussions on learning processes. A study by Bortoli et al. (2005) analyzed the dimensions of individual orientation and the perception of the motivational climate, identifying some elements in the Target model that allow educators/teachers to provide useful information to create a motivational climate oriented on competence.

The aforementioned design variables have been analyzed in a focused way; however, we are well aware of the complexity of an analytical study in the educational field since, as highlighted, the variables influence each other, sometimes resulting in unpredictable and unexpected educational repercussions. The systemic approach arises from this awareness with the aim of understanding how to exploit the educational effectiveness of these complex and dynamic interconnections in a functional way. Reasoning as an example on the time variable, one can reflect on the positivity in qualitative terms of the creation of some rest areas within the teaching proposal; the purpose of these areas inserted *ad hoc* is to allow a brief recovery to the students, overcoming a stress condition that is not only physiological, but also cognitive with the aim of filtering the achievement of an excessive stress phase capable of to trigger possible behavioral problems and / or unexpected manifestations. The dilution of the times in this sense, becomes a real decrease in the density of the *load*. As it happens in a workout when we increase the recovery times between one series and another to lower the load, in a very similar way it happens in this example, in which the *rest zones* lower the level of stress and amplify the possibilities of responding effectively to the proposals that will follow. What we want to highlight is that this time reduction inevitably acts systemically on cognitive processes, on the attentional focus and on the motivational aspects. It is precisely this systemic perspective that can give us a more functional reading of the intrinsic dynamics of the learning environments implemented from time to time.

Conclusions

As highlighted, the SAITinPEe is in an initial phase of study; it is intended to proceed with the analysis of the different variables and the interconnections between these and then proceed with the training of teachers and the subsequent experimentation of the model, also through research-action.

It is clear that there is an essential need for specific training for teachers to develop professional skills suitable for the implementation of this systemic approach to didactic design, even if it is not only the methodological competences that interferes with the realization of effective learning environments (lack of the teacher specialized in primary school, the structural and organizational problems of school institutions).

The complexity of the classes that characterizes the current scenario of contemporary society requires a great commitment and a strong sense of responsibility on the part of teachers in knowing how to respond adequately to different training needs.

To be able to design effective learning environments, providing appropriate and calibrated customizations of the didactic interventions in accordance with the heterogeneity of the class group is required a «reflective professionalism that must be supported, not so much by procedures to be followed in a rigorous way, but by tools to build situated learning environment, to be directors rather than performers» (Rossi & Giaconi, 2016, p. 7).

The systemic and non-linear logic highlights the impossibility of defining the design phases in a rigid and linear way; on a background of systematicity that methodologically guides the choices, a didactic action is grafted that is reflective and proactive following non-linear logics (Sibilio, 2014). The teacher modulates the teaching "in situation" through a continuous recognition of the learning environment, of the student / class group and of the "task" and proceeds in the modulation and re-modulation of his actions adapting to the situation. «The practice is not the implementation of a mere rationality, the result of a pre-established planning; it is constructed in a situation starting from micro decisions, from bricolage approximations and adjustments» (Altet, 2003, p. 37).

The Systemic Approach to Inclusive Teaching in Physical Education (SAITinPE), in the light of what has been highlighted in this study, has considerable potential in managing the complexity of teaching-learning processes and the group of conceptual ideas and methodological suggestions functional to the didactic action. The educational design of effective learning environments in PE plays a central role in guaranteeing the educational success of each student by enhancing the resources of the individual and of the entire class group. According to this perspective, the success is of the single student of the class group who supported him in the training path and of the teacher / educator, who is enriched in terms of self-efficacy, motivation and professional gratification.

References

Altet, M. (2003). *La ricerca sulle pratiche di insegnamento in Francia* (tr.it.). Brescia: La Scuola.

Bangsbo, J., Krustrup, P., Duda, J., et al. (2016). The Copenhagen Consensus Conference 2016: children, youth, and physical activity in schools and during leisure time. In *British Journal of Sports Medicine*, June 2016. doi:10.1136/bjsports-2016-096325

Beek, P.J. & Meijer. O.G. (1988). On the nature of the motor-action controversy. In: Meijer O.G., Roth, K. (Eds.). *Complex movement behaviour: the motor-action controversy*. Amsterdam: Elsevier Science, pp.157-85.

Beer, R.D. (2003). The Dynamics of Active Categorical Perception in an Evolved Model Agent. *Adaptive Behavior, 11*(4), 209–243. https://doi.org/10.1177/1059712303114001

Berthoz, A. (2011). *La semplessità*. Torino: Codice.

Berthoz, A., & Petit, J.L. (2006). *Phénoménologie et physiologie de l'action*. Paris: Odile Jacob.

Booth, T. (2011). The name of the rose: Inclusive values into action in teacher education. Prospects, 41(3), 303-318.

Booth, T., & Ainscow, M. (2008). *L'Index per l'inclusione* (tr. it.). Trento: Erickson.

Bortoli, L. & Robazza, C. (2016). L'apprendimento delle abilità motorie. Due approcci tra con-

fronto e integrazione. In *SdS/Scuola dello Sport*, n.109, pp. 23-34.
Bortoli, L., Bertollo M., Robazza, C. (2005). Sostenere la motivazione nello sport giovanile. Il modello Target. In *Giornale Italiano di Psicologia dello Sport*, 3(3), pp. 69-72.
Capra, F. (1996). *The Web of Life*, ISBN 0385476760.
Chow, J. (2013). Nonlinear Learning Underpinning Pedagogy: Evidence, Challenges, and Implications. In *Quest,* 65, pp. 469– 484. doi:10.1080/00336297.2013.807746.
Chow, J. Y., & Atencio, M. (2012). Complex and nonlinear pedagogy and the implications for physical education. In *Sport, Education and Society*, pp. 1–21.
Chow, J., Davids, K., Button, C. & Renshaw, I. (2015). *Nonlinear Pedagogy in Skill Acquisition: An Introduction*. New York, NY: Routledge.
Chow, J., Davids, K., Hristovski, R., Araújo, D. & Passos, P. (2011). Nonlinear Pedagogy:Learning Design for Self-Organizing Neurobiological Systems. In *New Ideas in Psychology*, 29, pp. 189–200.
Chow, J.Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I. & Araújo, D. (2007). The Role of Nonlinear Pedagogy in Physical Education. In *Review of Educational Research*, 77, 3, pp. 251-278.
Clark, A. (1997). *Being there: putting brain, body and world together again*. Cambridge MA: MIT Press.
Clarke, D. & Crossland, J. (1985). *Actions system: an introduction to the analysis of complex behaviour*. London: Methuen.
Colella, D. (2018). Physical Literacy e stili d'insegnamento. Ri-orientare l'educazione fisica a scuola. *Formazione & Insegnamento,* XVI(1), pp. 33-42.
Colella, D. (2019). Insegnamento e apprendimento delle competenze motorie. Processi e Relazioni. *Formazione & Insegnamento*, XVII(3), pp. 73-88.
Correia, V., Carvalho, J., Araújo, D., Pereira, E. & Davids, K. (2019). Principles of nonlinear pedagogy in sport practice, In *Physical Education and Sport Pedagogy*, 24, 2, pp.117-132.
D'Anna, C. (2020). L*ife Skills Education of Inclusion. Le potenzialità dell'Educazione Fisica e dello Sport a scuola*. Lecce: Pensa Multimedia.
Davids, K. & Araùjo, D. (2010). The concept of "organismic Asymmetric" in sport science. In *Journal of Science and Medicine in Sport* 13(6), pp. 633-640.
Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of skill acquisition: A constraints-led approach. Champaign*, IL: Human Kinetics.
Davis, B. & Sumara, D. (2012). Fitting teacher education in/to/for an increasingly complex world. Complicity. In *International Journal of Complexity and Education*, 9(1).
Di Gennaro D.C., Aiello, P., Zollo, I. & Sibilio, M. (2018). Agire didattico inclusivo: una questione di stile? In *Pedagogia più didattica*. Trento: Erickson.
Eggen, P. & Kauchak, D. (2001). Educational Psychology: Classroom Connections. 5th ed. New York: Macmillan.
Fogassi, L. (2019). *Neuroscienze dei sistemi motori cognitivi e applicazioni riabilitative. Atti del convegno*. Le proprietà cognitive del sistema motorio, i neuroni specchio e implicazioni per la riabilitazione, Monza, Aprile 2019.
Frauenfelder, E. (1994), *Pedagogia e biologia. Una nuova alleanza*, Napoli: Liguori.
Gallese, V. et al. (1996). Action, recognition in the premotor cortex. *Brain*, 119, pp. 593-609.
Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.
Gleick, J. (1987). *Chaos: Making a New Science*, New York: Viking.
Gomez Paloma, F. (2017). *Embodied Cognition. Theories and applications in education science*. New York: Nova Science Publishers.
Kelso, J.A.S. (1984). Phase transitions and critical behavior in human bimanual coordination. *American Journal of Physiology: Regulatory, Integrative and Comparative*, 15: R1000-R1004.
Kelso, J.A.S. (1995). *Dynamic Patterns: The Self-Organization of Brain and Behavior*. Cambrige: MIT Press.
Lakoff, G. & Johnson, M. (1999). *Philosophy In The Flesh: the Embodied Mind and its Chal-*

lenge to Western Thought. Basic Books.
Mandolesi, L. (2012). *Neuroscienze dell'attività motoria.Verso un sistema cognitivo motorio*. Milano: Springer.
McLennan, N., & Thompson, J. (2015). *Quality Physical Education (QPE): Guidelines for Policy Makers*. Paris: UNESCO Publishing.
Morin, E. (1977). *Il metodo, ordine, disordine, organizzazione*. tr. it., Feltrinelli, Milano, 1988.
Morin, E. (1999). *La testa ben fatta. Riforma dell'insegnamento e riforma del pensiero*. Milano: Editore Cortina Raffaello.
Mosston, M. & Ashworth, S. (2008). *Teaching physical education.* First on line edition available at: http://www.spectrumofteachingstyles.org/e-book-download .
Newell, K.M. (1986). Constraints on the development of coordination. In M.G Wade & H.T.A Whiting (Eds.) Motor development in children. Aspects of coordination ad control, pp.341-360. Dordrecht, Netherlands: Martinus Nijhoff.
Newell, K.M. (1986). Constraints on the development of coordination. In M.G. Wade & H.T.A. Whiting (Eds.) *Motor Development in children: Aspects of coordination and control.* pp. 341-360. Dordrecht, Netherlands: Martinus Nijhoff.
Pesce, C. (2002). Insegnamento prescrittivo o apprendimento euristico. *SdS-Rivista di cultura*, 55, pp.1-18
Pesce, C., Marchetti, R., Motta, A. Bellucci, M. (Eds.), (2015). *Joy of moving. Movimenti e immaginazione.* Torgiano-Perugia: Calzetti-Mariucci.
Port, R.F. & van Gelder, T. (1995). (Eds.). *Mind as Motion*, Cambridge, MA: MIT Press. Renshaw, I., Araujo, D., Button, C., Chow, J., Davids, K., & Moy, B. (2016). Why the Constraints-Led Approach is not Teaching Games for Understanding: a clarification. *In Physical Education and Sport Pedagogy*, pp. 459-480.
Renshaw, I., Davids, K., & Savelsbergh, G.J.P. (Eds.). (2010). *Motor Learning in Practice: A Constraints-Led Approach* (1st ed.). Routledge. https://doi.org/10.4324/9780203888100
Rivoltella, P.C. (2012). *Neurodidattica. Insegnare al cervello che apprende*, Milano: Raffaello Cortina.
Rizzolatti, G. & Sinigaglia, C. (2006). *So quel che fai. Il cervello che agisce e i neuroni specchio.* Milano: Raffaello Cortina.
Rossi, P.G. & Giaconi, C. (2016). Introduzione. In P.G. Rossi, C. Giaconi, *Micro-progettazione: pratiche a confronto. Propit, EAS, Flipped Classroom.* Milano: FrancoAngeli.
Rossi, P.G. (2011). *Didattica enattiva. Complessità, teorie dell'azione, professionalità docente*. Milano: Franco Angeli.
Sibilio, M. (2014). *La didattica semplessa*. Napoli: Liguori.
Sumara, D. & Davis, W. (2008). *Enabling Constraints: Using Complexity Research to 5 Structure Collective Learning Activities.* Communication to Teaching Games for 6 Understanding Conference, Vancouver, B.C., Canada, May 14th to 17th.
Syrmpas, I., Digelidis, N., Watt, A., Vicars, M. (2017). Physical education teachers' experiences and beliefs of production and reproduction teaching approaches. In *Teaching and Teacher Education*, 66, pp. 184-194.
Tan, C.W.K., Chow, J. & Davids, K. (2012). How Does TGfU Work?: Examining the Relationship Between Learning Design in TGfU and a Nonlinear Pedagogy. In *Physical Education and Sport Pedagogy*, 17(4), pp. 331–348.
Thelen, E. & Smith, L.B. (1994). *A dynamic systems approach to the development of cognition and action.* Cambridge, MA: MIT Press.
Thelen, E. et al. (2001). The dynamics of embodiment: a field theory of infant perseverative reaching, In *Behavioral and brain sciences,* 24, pp. 1-86.
UNESCO (2017). *A guide for ensuring inclusion and equity in educationand equity in education. The Global Education 2030 Agenda*. Paris: Unesco.
UNESCO (2019). *Final report of the International forum on inclusion and equity in education* –Every learner matters, Cali, Colombia, 11-13 September 2019.

UNESCO (2021). *Making the case for inclusive quality physical education policy development: A policy brief*. Paris, France.
Varela, F.J., Thompson, E. & Rosch, E. (1991). The Embodied Mind: Cognitive Science and Human Experience. Cambridge: MIT Press. (tr.it.) 1992, *La via di mezzo della conoscenza. Le scienze cognitive alla prova dell'esperienza.* Milano: Feltrinelli).
WHO (2001). *The International Classification of Functioning, Disability and Health (ICF).*
WHO (2007). *The International Classification of Functioning, Disability and Health (ICF-CY).*
WHO/Europe (2018). *Global action plan on physical activity 2018-2030: More active people for a healthier world*. Copenhagen.
Zambotti, F. (2015). *BES a scuola. I 7 punti chiave per una didattica inclusiva*. Trento: Erickson.

Normative references

MIUR (2009). *Linee guida per l'integrazione scolastica degli alunni con disabilità*.
MIUR (2012). Direttiva Ministeriale *Strumenti d'intervento per alunni con bisogni educativi speciali e organizzazione territoriale per l'inclusione scolastica, Indicazioni operative*, 27 dicembre 2012.
MIUR (2012). *Indicazioni nazionali per il curricolo per la scuola dell'infanzia e del primo ciclo di istruzione.*
MIUR (2018). *Indicazioni Nazionali e Nuovi Scenari.* Comitato Scientifico Nazionale per le Indicazioni 2012 della scuola dell'infanzia e del primo ciclo di istruzione, Roma.
UNESCO (1978). *International Charter of Physical Education and Sport*, approved at meeting in Paris 21 November 1978.
MIUR (2013). Circolare Ministeriale 06 marzo 2013, n. 8, prot. 561.
Legge 13 luglio 2015, n. 107. *Riforma del sistema nazionale di istruzione e formazione e delega per il riordino delle disposizioni legislative vigenti.*
D. Lgs 13 aprile 2017, n. 66, *Norme per la promozione dell'inclusione scolastica degli studenti con disabilità, a norma dell'articolo 1, commi 180 e 181, lettera c), della legge 13 luglio 2015, n. 107*, Gazzetta Ufficiale n.112 del 16-5-2017 - Suppl. Ordinario n. 23.
D. Lgs. 7 agosto 2019, n. 96. Disposizioni integrative e correttive al decreto legislativo 13 aprile 2017, n. 66, recante: «*Norme per la promozione dell'inclusione scolastica degli studenti con disabilità, a norma dell'articolo 1, commi 180 e 181, lettera c), della legge 13 luglio 2015, n. 107*».
MI, MEF, D.I., n.182 del 29/12/2020. *Adozione del modello nazionale di piano educativo individualizzato e delle correlate linee guida, nonché modalità di assegnazione delle misure di sostegno agli alunni con disabilità*, ai sensi dell'articolo 7, comma 2-ter del decreto legislativo 13 aprile 2017, n. 66.