

DOCTORAL THESIS



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DE MURCIA

INTERNATIONAL DOCTORAL SCHOOL

Doctoral Programme in Sports Sciences

The Concept Of System Thinking In Physical And Sport Education

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Supervisors:

Dr. D. Domenico Cherubini

Dr. D. Pietro Luigi Invernizzi

Murcia, May 2025

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AUTORIZACIÓN DEL DIRECTOR DE LA TESIS PARA SU PRESENTACIÓN

El Dr. D. Domenico Cherubini y el Dr. D. Pietro Luigi Invernizzi como Directores⁽¹⁾ de la Tesis Doctoral titulada “The Concept of System Thinking in Physical and Sport Education” realizada por D. Marta Rigon en el Programa de Doctorado Ciencias del Deporte, **autoriza su presentación a trámite** dado que reúne las condiciones necesarias para su defensa.

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COMPENDIUM OF ARTICLES

This Doctoral Thesis, "The Concept of System Thinking in Physical and Sport Education", adopts the format COMPENDIUM OF PUBLICATIONS. It shows a collection of cross-sectional and randomized controlled trial studies. The five articles which constitute this doctoral thesis have already been published and are presented below:

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Invernizzi, P. L., Rigon, M., Signorini, G., Colella, D., Trecroci, A., Formenti, D., & Scurati, R. (2022). Effects of varied practice approach in physical education teaching on inhibitory control and reaction time in preadolescents. *Sustainability*, 14(11), 6455.

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Rigon, M., Signorini, G., Scurati, R., Trecroci, A., Colella, D., Formenti, D., ... & Invernizzi, P. L. (2024). Relationship Between Multi-Teaching Styles and Didactics Effectiveness on Rugby Instructors and Minirugby Players. *Children*, 11(11), 1319.

Rigon, M., Signorini, G., Scurati, R., Trecroci, A., Colella, D., Formenti, D., ... & Invernizzi, P. L. (2024). Multisport-Integrated Training for Rugby Instructors: Success and Effects on Minirugby Players. *Journal of Functional Morphology and Kinesiology*, 10(1), 11.

RESUMEN

Las relaciones entre el individuo, el entorno y quienes le rodean constituyen el núcleo del desarrollo del individuo, ya que le convierten en protagonista de los cambios que se ejercen durante las interacciones y relaciones entre el mismo y el entorno, lo que a su vez puede obligar al individuo a una adaptación determinada por los condicionantes del entorno. En estas fases, el cerebro plástico del individuo se ve ampliamente estimulado por su entorno y las interacciones con él. Dicha estimulación contribuye al proceso de aprendizaje que conduce a la creación de nuevas conexiones neuronales que, a largo plazo, definen el comportamiento del individuo generado por las interacciones entre factores biológicos, ambientales y experienciales. Para comprender mejor las fases posteriores de este estudio, conviene tener en cuenta que cada elemento del sistema (microsistema) interactúa con los demás elementos a través de las relaciones entre dos o más microsistemas (mesosistema). Las situaciones que pueden influir en el entorno en el que se desarrolla el individuo representan el exosistema, que a su vez puede estar influido por leyes y creencias culturales (macrosistema).

Las recientes modificaciones del Artículo 33 de la Constitución Italiana (macrosistema) en septiembre de 2023, que inicialmente trataba de la libertad de arte, ciencia y enseñanza, se amplió para incluir el reconocimiento del deporte como elemento fundamental para el crecimiento individual y social. Este cambio constituye un paso importante hacia la valorización del deporte a nivel nacional, reconociendo su contribución a la educación, la socialización y la salud al hacer hincapié en el papel educativo, social y de promoción del bienestar psicofísico de la actividad deportiva. En esta visión, los clubes deportivos asumen un papel central desde el punto de vista educativo, con el objetivo de garantizar no sólo el éxito deportivo, sino también el éxito educativo de sus jóvenes miembros (micro y mesosistema). Por lo tanto, en una perspectiva de pensamiento sistémico que considere la sostenibilidad del propio club deportivo, la formación de instructores y entrenadores desde un punto de vista técnico y educativo es de fundamental importancia (exosistema). Del mismo modo, las Indicaciones Nacionales de 2012 y sus posteriores adiciones han influido y condicionado el sistema escolar italiano en los últimos años orientando las opciones didáctico-metodológicas de los profesores (aunque amparados por la ley que garantiza la autonomía escolar) hacia un enfoque transdisciplinar y multienseñanza que contemple el desarrollo de un determinado tema considerando el punto de vista de varias disciplinas.

Actualmente hay pocos estudios en Italia que interactúen con el sistema educativo escolar y deportivo con un enfoque de pensamiento sistémico, que pretende investigar las cuatro dimensiones que interactúan en el desarrollo del individuo, considerando las repercusiones e influencias que incluso pequeños cambios en diferentes niveles del sistema pueden desencadenar en cada parte y/o dimensión del mismo.

Este compendio de artículos ofrece una instantánea de algunas realidades locales italianas de los últimos cuatro años (2021-2024), a través del análisis de los contextos deportivo (natación y rugby) y escolar (primaria y secundaria).

El primer estudio situado en el contexto de la natación, realizado antes de la entrada en vigor de la enmienda del artículo 33 de la Constitución, tenía como objetivo investigar la eficacia del

aprendizaje de la técnica de natación en un grupo de niños de 5-6 años, comparando el uso por parte de los instructores de un método lineal y un método no lineal, la percepción de los niños y de sus padres sobre el uso de las diferentes metodologías. Los resultados mostraron una mayor preferencia por el método no lineal por parte de los niños y por el método lineal por parte de los padres.

El segundo estudio, situado en el contexto escolar, compara el uso de la práctica lineal constante, la práctica lineal variada y la práctica no lineal para evaluar su eficacia en el manejo de las funciones ejecutivas de un grupo de preadolescentes evaluados mediante la administración de pruebas de atención y capacidad de reacción. Los resultados mostraron mejoras notables en la capacidad de inhibición encontradas mediante el uso de la práctica lineal variada y, en general, surgió una mejora en las funciones ejecutivas con el uso de la práctica lineal variada y la práctica no lineal en comparación con el uso de la práctica lineal constante en preadolescentes.

El tercer estudio, enmarcado en un contexto escolar de primaria y secundaria de formación musical, tiene como objetivo evaluar la eficacia de la utilización de un método de enseñanza de carácter rítmico, en comparación con una propuesta didáctica tradicional para la enseñanza de la educación física, teniendo en cuenta las indicaciones nacionales de 2012 que promueven una orientación transdisciplinar en la enseñanza. En particular, se evaluaron los efectos de la intervención sobre la creatividad motriz, la percepción rítmica y los aspectos psicológicos, el contenido motriz de las clases y el tipo de estilos de enseñanza utilizados. Los resultados mostraron que la intervención tuvo un efecto directo sobre la creatividad motriz y la percepción rítmica. Sin embargo, mientras que el disfrute juega un papel mediador sobre la creatividad motriz, la autoeficacia no juega ningún papel mediador sobre las dos variables investigadas. Además, el uso de múltiples estilos de enseñanza en un enfoque rítmico permite una mayor implicación de los niños.

Los estudios cuarto y quinto se refieren en cambio a un contexto deportivo de rugby y se realizaron al mismo tiempo que entraba en vigor la modificación del artículo 33 de la Constitución italiana. El cuarto estudio se propuso investigar los síntomas que podrían interferir en la sostenibilidad del club deportivo, mediante una encuesta en profundidad orientada en dos frentes: el de los monitores y el de los niños a los que entrenan. La encuesta dirigida a los monitores describía el estado de sus competencias pedagógicas, metodológicas, psicosociales y socioafectivas. La encuesta dirigida a los niños, por su parte, investigaba la competencia motriz, los aspectos psicoafectivos y la capacidad de juego. Los resultados revelaron la presencia de síntomas como la falta de competencias pedagógicas y metodológicas (principalmente orientadas hacia estilos de juego) por parte de los instructores y de competencia motriz y capacidad de juego por parte de los niños. Teniendo en cuenta los resultados obtenidos anteriormente, se propuso a continuación un curso de formación multienseñanza y multideporte organizado en forma de taller, cuya eficacia y transferibilidad se evaluó en el grupo de instructores y en el grupo de niños entrenados por ellos en el quinto estudio, mediante comparación con un grupo de control en el que no se propuso el curso de formación. Los resultados mostraron una mejora de las competencias pedagógicas y metodológicas de los instructores que abordaron una metodología multienseñanza, y una mejora de las competencias motrices, psicológicas y de juego en los niños cuyos instructores asistieron al curso de formación.

PALABRAS CLAVE

Multi-enseñanza, Monitores deportivos, Profesorado de escuela, Educación física, Práctica deportiva

TERMINOS TESAURO

Desarrollo Humano, Enseñanza programada

ABSTRACT

The relationships between the individual, the environment, and those around him or her constitute the core of the individual's development, as they make him or her the protagonist of the changes exerted on the environment as an effect of his or her interactions and relationships, which can, in turn, force the individual himself or herself into an adaptation determined by environmental constraints. During these stages, the individual's plastic brain is extensively stimulated by its environment and interactions. Such stimulations contribute to the learning process that determines the creation of new neuronal connections that, in the long run, define the individual's behaviour generated by the interactions between biological, environmental and experiential factors. To better understand the next steps of the present study, it is good to consider that each system element (microsystem) interacts with other elements through relationships between two or more microsystems (mesosystem). Situations that can influence the environment in which the individual develops represent the exosystem, which can be influenced by cultural laws and beliefs (macrosystem). The recent amendments to Article 33 of the Italian Constitution (macrosystem) that occurred in September 2023, which initially dealt with freedom of art, science, and teaching, was expanded to include recognition of sports as a fundamental element for individual and social growth. This change is an important step toward enhancing the value of sport at the national level, recognizing its contribution to education, socialization and health by emphasizing the educational, social and psychophysical well-being-promoting role of sporting activity (Parlamento Italiano, 2023). In this vision, sports clubs assume a central role from the educational point of view, with the aim of ensuring not only the sporting success but also the educational success of their young members (micro- and mesosystem). Therefore, from a system thinking perspective, considering the sustainability of the sports club itself, training instructors and coaches from a technical and educational point of view is of fundamental importance (exosystem). Similarly, the 2012 National Directions and their subsequent additions have influenced and conditioned the Italian school system in recent years by orienting teachers' didactic-methodological choices (albeit protected by the law that guarantees school autonomy) toward a transdisciplinary and multi-teaching approach that involves the development of a given topic by considering the point of view of multiple disciplines. At present, little is known about the studies in Italy which interface with the school and sports

education system using a system thinking approach. This approach aims to investigate all four dimensions that interact in the development of the individual, considering the repercussions and influences that even small changes at different levels of the system can trigger on each part and/or dimension of it.

This compendium of articles reports a snapshot of some local Italian realities over the past four years (2021-2024) through an analysis of the contexts of sports (swimming and rugby) and schools (primary and secondary school).

The first study set in the swimming context carried out before the amendment of Article 33 of the Constitution came into force aims to investigate the effectiveness of learning swimming technique in a group of 5-6-year-old children, comparing instructors' use of a linear method and a nonlinear method, of children's and their parents' perceptions of the use of the different methodologies. The results showed a greater preference for the nonlinear methodology by the children and for the linear methodology by the parents.

In contrast, the second study, set in the school context, compared the use of constant linear practice, varied linear practice, and nonlinear practice to assess their effectiveness on executive function management of a group of preadolescents assessed through administering tests for attention and reaction skills. The results showed noticeable improvements in inhibition ability found through the use of varied linear practice and, in general, improved executive functions that emerged from the use of varied linear practice and nonlinear practice compared with the use of constant linear practice in preadolescents.

The third study, set in a music-training primary and secondary school context, aimed to evaluate the effectiveness of using a rhythm-oriented teaching method compared with a traditional teaching proposal for physical education teaching, considering the 2012 national guidelines that promote a transdisciplinary orientation in teaching. In particular, the intervention's effects on motor creativity, rhythmic perception, and psychological aspects, as well as the motor content of the lessons and the type of teaching styles used, were evaluated. The results obtained showed that the intervention had a direct effect on motor creativity and rhythmic perception. However, while enjoyment mediates motor creativity, self-efficacy does not mediate in the two variables investigated. In addition, using multiple teaching styles in a rhythmic approach allows children to become more involved. On the other hand, the fourth and fifth studies refer to a rugby sports context and were carried out when the amendment to Article 33 of the Italian Constitution came into effect. The fourth study aims to investigate the symptoms that could interfere with the sustainability of the sports club through an in-depth survey oriented on two fronts: that of the instructors and that of the children they coach. The survey aimed at instructors described the state of the art of their teaching, methodological, psychosocial and socio-affective skills. On the other hand, the survey aimed at children explored motor competence, psycho-affective aspects, and the ability to play. The results revealed the presence of symptoms such as lack of teaching and methodological skills (mainly oriented toward play styles) on the part of instructors and motor competence and play skills on the part of children. Taking into account the results previously obtained, a multi-teaching and multisport training course organized in a workshop mode was then proposed, the effectiveness and transferability of which were evaluated on the instructors' group and the children's group they

coached in the fifth study through comparison with the control group in which the training course was not proposed. The results showed an improvement in the teaching and methodological skills of the instructors who approached multi-teaching methodology and an improvement in motor, psychological and play skills in the children whose instructors attended the training course.

KEYWORDS

Multi-teaching, Sports instructors, School Teacher, Physical Education, Sports practice

THESAURUS TERMS

Human development, programmed teaching

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Undertaking and completing a PhD path requires the ability to express an idea and find its applicability to the context, consider the influence of multiple variables, and take into account the contribution of certain factors that, even in a small part, can significantly change the path (leverage points), establish necessary boundaries (silos) to the research project, and foster and consider the establishment of relationships and interconnections of the various elements and people that are part of it, just as in a System thinking approach.

My journey has also been characterized by the interconnectedness of many variables and elements and supported by reflections. How to reconcile my passion for rugby, which has kept me on the field for ten years now, with my passion for music and teaching? This reflection inspired the idea to rethink an approach to conceive a new vision of the school and sports system using the System Thinking concept by approaching the model with two exploratory studies in the field of sports and schools. My creativity, curiosity, and desire to explore, however, required the need to place limits (silos) on the variables to be analyzed in the research project (which are numerous), so mainly the variables most common to the studies will be analyzed. It has been a nonlinear, imperfect, but full journey, marked by satisfactions and downfalls (leverage points), which kept me away from research for a year but made me realize how much I actually wanted to complete this journey, which I enthusiastically embraced the exact moment it was proposed to me at the beginning. The richness of this experience, however, would not have been possible without the opportunity to have formed relationships with the people who supported and accompanied me on this journey. The greatest gratitude goes to Dr. Professor Domenico Cherubini of the Universidad Catolica San Antonio de Murcia who guided and directed me along the path of my professional growth, and to Dr. Professor Pietro Luigi Invernizzi of the

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" Todos los niños nacen artistas. El problema es cómo
seguir siendo artistas al crecer" Pablo Picasso

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ABBREVIATIONS

A Automaticity

ANOVA Analysis of Variance

ANOVA RM Analysis Of Variance Repeated Measures

Av Average

BMI Body Mass Index

Bpm Beats per minute

CET Cognitive Evaluation Theory

Ch-CON Children-Control group

Ch-IAC Children of the Instructors Attending the Course

CHI Children

CI Confidence Interval

CLP Constant linear practice

CV Coefficient of variation (expressed as a percentage $CV\% = (\text{Standard Deviation}/\text{Mean}) \times 100$)

DC Distraction Control

DM Decision Making

DMA Divergent Movement Ability

DV Dependent Variable

ER Emotion Regulation

ES(s) Effect Size(s)

EST Empathy Scale for Teachers

FIN Federazione Italiana Nuoto

FIR Federazione Italiana Rugby

GPAI Game Performance Assessment Instrument

GS Goal Setting

Hi High

I-CON Instructors Control group

IAC	Instructors Attending the Course
IC	Impulse Control
ICC	Intraclass Correlation Coefficient
IESPES	Internship Evaluation Sheet in Physical Education and Sports
IFITS	Identify the Teaching Styles
IV	Independent Variable
KTK	Körperkoordinationstest für Kinder
LI	Linear pedagogy
Lo	Low
MedV	Mediator Variable
MeE	Enjoyment Mediation analysis
MeP	PAQ-C Mediation Annalysis
MeS	Self-efficacy Mediation 25analysis
MG	Multi-teaching Group
MoD	Didactical competencies moderation analysis
ModV	Moderator Variable
MoM	Methodological competencias Mediation 25nálisis
MQ	Motor Quotient
MVPA%	Moderate to Vigorous Physical Activity %
NI	No-rhythm-based intervention
NL	Non-Linear Pedagogy
NLP	Non-linear practice
NMG	No-Multi-teaching Group
PACES	Physical Activity Enjoyment Scale
PAQ-C	Physical Activity Questionnaire for Older Children
PE	Physical Education
PHY	Physical Literacy
PMSC-2	Pictorial Scale of Perceived Movement Skill Competence for Young Children

PSES Physical Self-Efficacy Scale

QS Questionnaire of Satisfaction

RI Rhythm-based intervention

SCQ Self-Control Questionnaire

SD Standard Deviation

SDT Self Determination Theory

SM Self-Monitoring

SOFIT System for Observing Fitness Instruction Time

ST System Thinking

TEA Teacher

TI Task Initiation

TSQ Teaching Styles Questionnaire

VLP Varied Linear Practice

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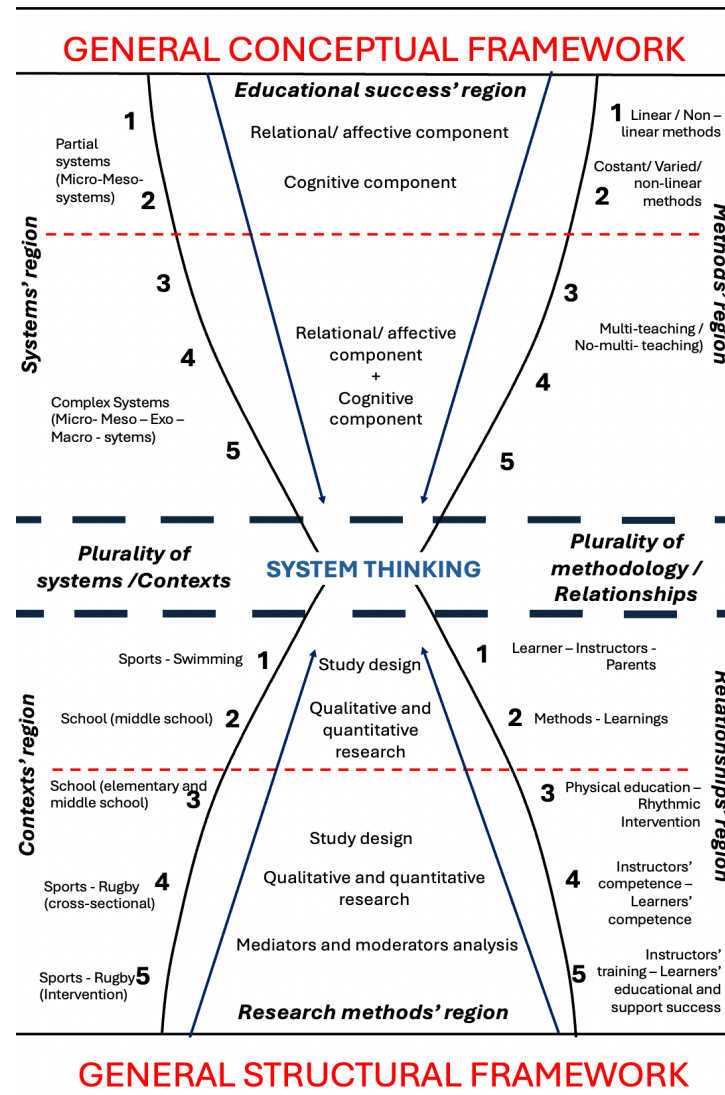
I – GENERAL INTRODUCTION

I - GENERAL INTRODUCTION

1.1. EXPLANATION OF THE FRAMEWORK

Figure 1 highlights the study's conceptual framework, which is characterized by a General Conceptual Framework and a General Structural Framework.

Figure 1. Scheme related to the General Conceptual Framework and General Structure Framework of the study



The numbers highlighted in the diagram (1,2,3,4,5) correspond to the articles published in scientific journals Q1 and Q2 and represent the investigations conducted in the present project.

Investigations 1 and 2 represent exploratory analysis studies.

Investigations 3, 4 and 5 represent the detailed final and integrated identification construction of all elements of System Thinking applied to Physical and Sports Education.

The following three regions characterize the general conceptual framework:

- The region of systems
- The region of methods
- The region of educational success

The studies 1 and 2 (exploratory studies), in the region of systems, highlight the concepts of micro- and mesosystems.

In studies 3, 4 and 5 (detailed studies), the exo- and the macrosystem also appear.

The red dotted line between number 2 and 3 in the framework divided the exploratory studies from the detailed studies.

The methods region highlights in studies 1 and 2 (exploratory type) the analysis of comparisons between the linear and nonlinear methods and between varied, nonlinear and constant practice methods.

In investigations 3, 4, and 5 (detailed studies), considering the previous analyses, the research moves towards an integrated approach of multiple methods.

The educational success region highlights an analysis oriented to the relational and affective components in study 1 and an analysis oriented to the cognitive components in study 2.

In studies 3, 4, and 5, all these components are taken into account in an integrated approach to reflect on educational success overall.

The general structural framework is characterized by:

- The region of context (sports and Physical Education)
- The region of relationship
- The region of research methods

The region of sports and Physical Education contexts is highlighted in the preliminary and exploratory studies (1, 2), and an analysis of these contexts is also taken up and carried out in the detailed studies (3, 4, 5). In the sports context, the investigations involved "the swimming pool" and "the rugby environment." In the Physical Education context, the investigations involved elementary and middle schools.

The region of relationships between the elements is characterized by the following interactions:

- learners, instructors, parents,
- methods, learning,
- physical education, rhythmic intervention,
- instructors' competence, learners' competence,
- instructors' training, children's educational success.

The region of research methodology considered the ensemble of qualitative and quantitative research elements and a progressive inclusion of analyses of mediators and moderators complementary to the analysis of the effects of independent variables on dependent variables.

The six regions analyzed flow into the System Thinking core (as the arrows explain) by comprehensively investigating various systems/contexts and methodologies/relationships.

1.2. ECOLOGICAL DYNAMICAL MODEL FROM BRONFENBRENNER'S (1977: 1979) AND COTE'S (2007) MODELS TO A NEW PERSPECTIVE: INVESTIGATION ELEMENTS

Children's development is influenced by the active interrelationship they have with the environmental system (Bronfenbrenner, 1977). The relationship that the child has makes him an active actor who influences his/her environment, which in turn forces him to adapt to its constraints.

The environment can be seen as made up of different dimensions placed one inside the other, interrelated in micro-, meso-, exo-, and macrosystems, thanks to the influence of the child's behaviours (Bronfenbrenner, 1979).

The microsystem consists of participants, a physical domain, a location and a program of activities (Côté et al., 2007). The microsystem is the closest environment in which a child can have direct contact and establish relationships (from the child and to the child) (Bronfenbrenner, 1979). The mesosystem is based on the interrelationships between two or more microsystems involving the developing person (Côté et al., 2007). The exosystem represents the dimension where the developing child interrelates with situations affecting his environment. The macrosystem comprises the cultural and social forces that impact human development (Côté et al., 2007).

1.2.1. Microsystem

Children, preadolescents and their peers are the main actors in their development (Côté et al., 2007). Everyone is unique and is influenced by other people, the environment and the context in which he/she is placed. During his/her development, the child crosses different stages, which influence the body (as image, motor competence and perception), brain and learning (emotional brain, logical brain, developing executive functions), self-efficacy and enjoyment.

Parents are the closest people to children, which rear them according to their beliefs and mainly affect their attitude and behaviour. They generally act modelling their parents' behaviour, as they were parented or learning to grow up children being raised, or according to information acquired about the nature of parenting, or through the attitudes, beliefs, thoughts and feelings that are activated during parenting (Grusec & Danyliuk, 2007) These aspects can also influence the psychomotor development of the children (Invernizzi et al., 2021)

Sports instructors (i.e. swimming and rugby instructors) are the closest people dedicated to the child's psychomotor development in different environments (swimming pool, rugby field) and directly influence their physical literacy. They influence children's motor development according to their pedagogical, sports, and motor background and specific sports education acquired from federal courses. Generally, sports instructors are retired athletes (especially for swimming), parents or rugby enthusiasts offering to become instructors who have followed the Federal courses (Federazione Italiana Nuoto, 2021; Federazione Italiana Rugby, 2023).

Teachers (physical education teachers, multipurpose teachers and discipline teachers) influence children's learning and education. Until a few years ago, elementary school teachers used to delegate the teaching of Physical Education to projects coordinated by local Universities in collaboration with CONI (e.g., Project SBAM, Class Sports) (Colella et al., 2017; Matteucci, 2017; Pesce et al., 2020). Recently, Physical Education teachers in Italy can work on children's motor development from the 4th grade of elementary school to the 5th grade of high school, and they have received a university education at the Sports Science Faculty (from 1999) or at ISEF (until 1998) (Parlamento Italiano, 1998; 2021). Teachers at elementary school are multipurpose teachers with a primary school teacher degree oriented to pedagogical and didactical principles. Disciplined teachers (middle and high school) are graduates of a specific area who have been trained to become teachers.

Learnings and behaviors (motor, cognitive, and affective) depend on social competencies, which can be influenced by and acquired through the interrelation with context, environment, and people, which expose the developing person to experiences.

Contexts (school, swimming school, rugby school) can intervene differently on the developing person depending on the background which is inserted in (culture, geographical location, infrastructures, policy).

The methods used by instructors and teachers can influence the learning of developing people. A linear approach in sports and physical education affects motor competencies more, while a non-linear approach influences soft skills more (Invernizzi et al., 2021). Using reproductive teaching styles acts more on the physical dimension of the developing person; using productive teaching styles develops the social and cognitive domains. Using a multi-teaching style lets the teacher reach and act on different dimensions of the children according to their motor and psychosocial needs (Invernizzi et al., 2019). Similarly, a multisport approach applied in sports practice can improve different motor skills by exposing the children to different contexts, avoiding boredom, limiting drop-outs, and developing an autonomous decision-making and game capacity (Kirk, 2005; Pesce et al., 2013).

Didactics is the science of education, and it comprises all the aspects related to the need for supportive communication (Ntoumanis et al., 2017), organizational

competencies (Kirkpatrick & Kirkpatrick, 2006), social and personal competencies and technical competencies.

Communication can influence the child's sphere through the tone of the voice, the timber, the gesture, the mimic, the voice volume, and the use of images and metaphors. The communication channel must be set up according to the interlocutor's phases of development (child or preadolescent), considering the cognitive development as well (emotional brain, logical brain, difficulty managing executive functions).

Good organizational skills help to avoid downtimes, optimizing the time available for the lesson, which can be used to improve skills (motor and psychosocial skills). In conclusion, having proper technical and social competencies could facilitate improving and learning new motor competencies and establish a relationship with the developing person.

1.2.2. Mesosystem

The mesosystem is the dimension of the relationships between two or more microsystems, which involves learning, educational processes, and human development.

The relationship between the instructors and children is crucial for the children's psychomotor development. It depends on the social competencies of the instructors, which can stimulate the attention and curiosity of the child through active involvement, which lets the instructor observe what the child already knows to do and what is necessary to learn (Langendorfer, 2012; Wiśniewska, 2016). In addition, children interacting with peers and instructors can develop language and social skills and self-awareness (Tran, 2013; Vygotsky & Cole, 1978). The relationship between instructors and children directly impacts a child's soft skills development. In 5-year-old pupils, the connection with the teacher is peculiar to build the child's personality, and it is a quiet parental relationship. As the child grows, the instructor can guide him/her in managing and mediating the relationship with peers, and during preadolescence, guys experience an imbalance of emotions and feelings, which leads to impulsive behaviour caused by the

immaturity of the prefrontal cortex and the critical inhibitory control (Arain et al., 2013).

The instructor mediates the improvement of self-awareness, allowing the children to take pleasure from the motor practice, stimulating them to seek more motor experiences and increasing their self-esteem. A constant and healthy motor practice can also help preadolescents manage their critical stage.

The instructors must also manage the relationship with the parents since parents entrust their children to instructors. Instructors must support and ensure parents with their doubts about the maturation of their children's motor development, which is not the same for every child. Parental involvement in infant motor practice can enforce the parent-child interaction and their relationship. Many parent-child courses are provided in swimming (Borioni et al., 2022) and rugby (since 2006, with Rugbytots). Children in swimming and rugby can approach the practice from 2-3 years old, spending the activity with their parents and being guided by the instructors.

Moreover, parents appreciate it when instructors actively organize the activity or interact directly with 5-year-old children to build trust (Invernizzi et al., 2021). Nonetheless, instructors can be a bridge between parents and guys during the critical stage of their development during preadolescence. Preadolescents tend to remove the reference adult (i.e. parents) conditioned by the need to affirm their own identity and recognize them through their peers, so the instructors could be a reference point out of the family during this stage. Moreover, supportive parenting during the early stage of preadolescence could avoid life's adversities (Brody et al., 2017), whether aggressive parenting is related to alterations in the development of the prefrontal cortex in adolescents (Whittle et al., 2016).

A similar context can be experienced in the relationship between teachers and children in the school context. Teachers must transmit knowledge and have an educational function by accompanying the child's psychosocial and motor development step by step.

In the first year of infant and elementary school (until 2nd grade), schoolteachers have a strong relationship with their children due to their egocentrism and need to be viewed and supported by the adult in mediating the relationship with their peers. During the last year of elementary school, the

mediating function of the teacher with the peers progressively decreases and changes to stimulate the interrelationship with the peers. During preadolescence, guys try to push away the adult figure to find their own personality. However, they also need a reference point to guide and support them "from afar", developing and using empathy and self-control capacities.

From the point of view of the relationship between methods and learning, using different teaching methods lets the teacher reach the multiple dimensions of the developing person. Teachers have different "tools of the trade" that can be used in different contexts with different people (infants, children, and preadolescents). Teachers can use a linear or nonlinear approach according to the objects and needs of the developing person. A linear approach can increase children's motor competence more than a nonlinear approach (Invernizzi et al., 2021). Moreover, a discrepancy can be viewed in perceived motor competence, which is higher in children enrolled in a nonlinear approach in the infant group (Ilyka et al., 2021). Infants also love repetitions (rituals, games, activities) in organizations because they know what could happen later. A nonlinear approach, children-oriented, can reduce the intra-groups' motor competence gap, favouring homogeneous learning. A child-centred approach can also increase peer interaction through cooperative learning and psychosocial skills (Bessa et al., 2019; Invernizzi et al., 2021). In the school context, a rhythmic approach based mostly on reproduction styles can involve children and preadolescence in school motor practice during P.E. lessons to develop motor creativity (Rigon et al., 2024b). In the sports context (i.e. rugby), the use of a multi-teaching and multisport approach allows children to increase their motor competence, psychosocial skills and game competence, using both productive and reproductive styles and enriching the motor practice with other sports and activities different from rugby (Rigon et al., 2024a). A varied linear approach and a nonlinear approach are favourable for use with preadolescents to enhance executive functions. It can be peculiar to foster individualized learning strategies, metacognition and intrinsic motivation in middle-school students (Bessa et al., 2019; Invernizzi et al., 2022).

To explain the relationship between didactics and learning, the development of the brain, which crosses different stages during the person's maturation, must be taken into account. Children learn more through games, images and metaphors until they are seven years old. They learn more during this phase due to a lower

frontal and prefrontal cortex maturation and a greater limbic system involvement in learning. From eight years old, they started to involve the logical brain due to the development of the abstraction capacity. According to this, their learning capacity changes, and the teacher has to have an excellent capacity for involvement and be empathic with the developing person. Teachers/Instructors must use mimics, metaphors, imagination, and creativity to engage the children and get them involved in the learning process. The use of Need Supportive Communication is peculiar to support the children in developing autonomy, motor competence and relationships with others (peers and adults) to promote active involvement (Dehaene, 2020). Communication must be used in all aspects, varying tone, timber, and proxemics. Also, the organizational and management aspects are fundamental for a successive education to avoid boredom, downtimes, children's lower attention and consequent dispersion.

The aquatic environment has a crucial role in the development of younger than 5-year-old children because they need a long psychological adaptation before moving confidently using aquatic skills (Torlakovic et al., 2018). Previous studies were conducted to establish children's age to approach swimming to reduce the risk of drowning and improve basic aquatic skills. Infant swimming practice (2-3 years old) can influence swimming behaviours through a feedback system provided by the aquatic environment to the child that influences his/her sensory-motor, central and peripheral nervous system development and psychosocial behaviour (Zelazo & Weiss, 2006).

Rugby has to prepare individuals for life since the aim is "to raise men/women athletes able to face the adversities of life." According to this, a person involved in rugby is a rugby man, not a rugby player. Through a multisport approach in rugby, players can be able to use and face different situations with a great opportunity of tools given by the situational nature of the game.

The school aims to help children and adolescents develop soft skills to face adversities. Schools can approach this topic using a transdisciplinary approach, which allows students to consider topics and problems from different points of view in order to solve them.

1.2.3. Exosystem

Exosystems are situations that affect the relationship that emerges from the mesosystem (Côté et al., 2007).

Teachers' training can influence the development of children and preadolescents. As reported before, elementary school teachers are graduates who attended the Primary school teacher faculty and have acquired and internalized the pedagogical and didactical principles essential to teaching and establishing relationships with children, both with lecturers and during their internship.

Middle school teachers are graduated people who do not essentially (except for Physical Education teachers, whose university plan includes courses in pedagogy, psychology and didactics of sports and motor activity) have a pedagogical and didactical background. To be hired permanently in the school, they must attend the teaching certificate courses, where pedagogy and didactics are provided. A teacher must recognize critical signals of discomfort since a poor competent teacher can dramatically affect the psychological and social development of the developing person. Schools should provide training courses aimed at the prevention of bullying, eating disorders, self-injurious or suicide-prone practices, and sensitive topics that may involve preadolescents (Albayrak et al., 2016; Favaro et al., 2005; Kallestad & Olweus, 2003; Haugen et al., 2023; Van Aalst et al., 2024)

The instructors' training is an issue that needs to be given even more attention since most sports instructors are retired athletes, parents, or enthusiasts who approach coaching youth categories. In Italy, a rugby coach must attend a video course provided by FIR, during which a test must be done at the end of every module. Every course is specific for the category trained. After acquiring the preliminary competencies, a five-hour practical internship must be attended. The instructor must complete the training in two years, be present in the game list of the category trained, attend upgrading federal courses, show a one-week planning to the tutor, and have been tutored by the federal tutor assigned for at least two trainings (Federazione Italiana Rugby, 2023).

The training course does not offer the possibility of acquiring didactical and methodological competence and training it through specific internships, as literature proposes (Kirkpatrick & Kirkpatrick, 2006). The presence of motor

science faculty in the territory can encourage the relationship between the sports society and the higher education center to improve the quality of instructors through proactive laboratories, internships, and lectures conducted by experts (Rigon et al., 2024b; 2024a).

1.2.4. Macrosystem

From an ecological-dynamical point of view, macrosystems are represented by the cultural and social forces that impact the system (Côté et al., 2007).

In our concept, the Italian Constitution and Scholastic Laws are the main forces that can impact and condition the system.

The modification of the art. 33 in the Italian Constitution changed the view of the sports society, which acquired the role of education centres (Parlamento Italiano, 2023). According to this aspect, instructors cannot only be trained in technical and tactical aspects, but they must also acquire pedagogical, psychological, didactical, and methodological competencies. Entities must develop sports societies in their territories, the centers where educational success can be promoted. In addition, the presence of Motor Science Faculty in the territory could be an important resource, which the sports clubs, in agreement with the municipality and other entities, should exploit to grow their instructor training to improve the quality of their educational centers (Rigon et al., 2024a).

The "Indicazioni Nazionali" provides the school program, which contains the educational objects that children and preadolescents must reach at the end of the cycle. Indicazioni Nazionali suggests that schools (according to the scholastic autonomy and their geographical location, regional laws, and entities) establish connections with the territory promotional entities to develop projects involving schools and children to become active citizens. Indicazioni Nazionali also invites teachers to educate children through a transversal and transdisciplinary approach, which is addressed to the development of soft skills such as entrepreneurship, problem-solving, teamwork, creativity, critical thought, stress management, flexibility and empathy (MIUR, 2012).

1.3. RELATIONSHIP BETWEEN BRAIN AND BEHAVIOUR

1.3.1. From a Deterministic Brain Concept to Brain Plasticity: the Evolution of the Developing Brain

Until the end of the 70s, the clinical environment was used to think that a damaged brain could not be rehabilitated. The only way to manage a damaged brain was conservative therapy, which in Italy consisted of interning people with psychological diseases in psychiatric hospitals (until 1978 in Italy with Basaglia's law, which established the closures of mental hospitals) (Parlamento Italiano, 1978). The studies conducted in the 80s and '90s showed a different scenario, in which it is possible to affirm that the brain consists of two parts: one determined with birth, which is slightly modifiable and a plastic part, which is able to be modified through experiences. The first consists of several neural specialized circuits determined by genes and selected by evolution. This organization lets the children have intuitions in many fields of knowledge, such as the physical nature of the objects and their behaviour, the ability to explore space using neural maps, intuitions on numbers, mathematics and probability, feel effect for humans and language skills (Dehaene, 2020; Goldberg, 2018; Graven & Browne, 2008; McGraw, 1946). However, the brain is not only determined; it can also learn through the environment, the experiences and the interactions, which modulates and modifies the neural circuits. The neurons actively involved in brain plasticity are located in the frontal and temporoparietal areas, where a real laboratory continuously integrates and restructures neuronal processes (McGraw, 1946). Neuronal aggregations establish the types of connection that determine the different behaviours of the individual. The individual's behaviour is modifiable due to the changes and interaction of three factors (biology, experience, environment) (Graven & Browne, 2008; McGraw, 1946; Toga et al., 2006). Behaviour does not depend on the neurons but on their organization and interactions in little nets to create different adaptive responses to experiences and to the environment. Memory depends on the different structures of neurons that are activated, modified, and reorganized in the brain, and biology, environment and experiences play a key role in this process. Stimulating the growth factors and the neurons to form a determined structure changed the behaviour, and the learning of different motor competencies and their perception is favoured. According to Hötting and Röder,

2013 aerobic exercise induces beneficial effects on brain functions due to the changes in blood flow and vascularization in the prefrontal cortex, which provides better oxygen and nutrients and stimulates growth factors such as BDNF during activity in acute exercise and IGF-1 after activity in chronic exercise (Hötting & Röder, 2013). Physical exercise combined with cognitive stimulation affects the hippocampus, which is critical for improving learning, memory and spatial navigation (Khalil, 2024), and the spatial learning ability (Hötting & Röder, 2013), which are important for children/learners to interact with the environment constitute by its characteristics (water or field exploiting the resistance of the fluid or the soil spring back during running) other children/players (spatial perception in water and on the field due to the distances from the other mates or the try line, trajectories, running lines of the mates and the opponents), use of objects (distances between the swimmer and flotation devices or between the ball and the player/mate).

Combining physical activity and cognitive challenges should induce beneficial effects on brain structure and function (Hötting & Röder, 2013). Environmental enrichment and complex learning tasks promote neurogenesis and hippocampal plasticity (Khalil, 2024).

Personal experiences and how they are lived indicate how much the brain depends on individual experiences. The neural basis of experience-dependent processes involves generating new synaptic connections responding to events that furnish the information to be memorized (Greenough et al., 1987).

Learning to teach literature is difficult because it involves eradicating or disrupting notions about self and others. Personal beliefs determine how much knowledge the teacher gains from a training program and how it is interpreted (Kagan, 1992).

Studying a damaged brain helps scientists investigate how a healthy brain is structured and functions. Based on the studies conducted, neurologists can state that the left hemisphere is a repository of accumulated experiences about the world. People represent these experiences as patterns through which new information can be interpreted (Goldberg, 2018). A pattern is a strictly interconnected net of neurons in which if an outside sensorial input activates a part of the net, the rest of the net is activated, too. Through this mechanism, the brain recognizes an object as a member of the familiar category. Sometimes, the

mechanism of pattern recognition can interrupt its function due to brain damage. These conditions are called associative agnosia, when the patient cannot recognize objects, and apraxia when the patient loses motor ability to manage.

The study of agnosias helps neurologists discover that patterns are distributed in different areas as the varied attributes of the brain stand in different areas of it since information is not totally damaged in agnosias. This assumption has led to the discovery that the brain can be rehabilitated through therapy that promotes the reconnection of damaged neural circuits (Goldberg, 2018). Hebbian's learning mechanisms play an important role in this process. A slight loss of connectivity can be recovered autonomously; a significant loss of connectivity could lead to a permanent loss of functionality, so a compensatory approach is needed (Robertson & Murre, 1999). Hebb's connectionist theory of learning suggests that a simultaneous activation of two neurons or a group of neurons induces a permanent modification, strengthening the synaptic connection. Hence, two nerve cells are simultaneously activated several times, enabling a neuron to activate the other, fostering a growth process through metabolic changes that enhance the efficiency of the cells (Hebb, 2005).

Birth stimulates and increases the number of experiences that the baby can afford. Some synaptic nets' activation increases and strengthens, creating stronger and more complex connections.

Different parts of the brain mature at different times due to endogen factors and environmental needs. From 3 to 6 years old, the increase in myelination and synaptic connections contribute to the development of the brain in the frontal cortex (Graven & Browne, 2008).

During this stage, the language ability drastically increases. Language is a communication skill aimed at generating affirmations and representing the environment around the developing person. The ability to abstract was peculiar for primates to create the first words of a protolanguage. Nowadays, the ratio between perception and language is inverted in modern children. Children learn to organize and model the physical world through language learning (Goldberg, 2018). At the same time, the aquatic environment at an early age stimulates socio-relational skills, and children develop and increase their language skills (Diem, 1982; Kliorin & Aleksandrovich, 1989; Mæland, 1992). The interactions with teachers and peers, due to the development of language skills, make the child more self-confident.

In the human brain, language is in the left hemisphere (like the physical world representation, and their cortical representation is distributed and associated). It gets inserted into a brain structure already present in other primates due to the greater dimension of the temporal planum, the pars opercularis and the pars triangularis in the left hemisphere than in the right one, which is peculiar for the recognition and production of speech (Goldberg, 2018). A child's brain is both structured and plastic. From birth, children have specialized connections determined and selected by evolution. This organization lets them develop intuition in many fields of knowledge, such as the physical nature of objects and their behaviour, perception of the maps and spatial orientation, intuition about mathematics and probability, and an inclination for languages (Dehaene, 2020). Environment and experiences influence the child's behaviour since brain circuits and connections can interact with the physical world and experiences, generating learning. In the beginning, the child has an overproduction of neural circuits, so he/she can explore and know the world with several possibilities than an adult (Dehaene, 2020; Graven & Browne, 2008; Toga et al., 2006). After a few years, many neural synapses are selected and eliminated to use and maintain the most useful circuit, so the brain becomes more specialized and stabilized. The first areas that reach stabilization are the auditory areas, which converge to pronouncing the vocals in their mother language. In a few years, a child becomes native to a specific language, culture and costume during the sensitive period of brain plasticity (Dehaene, 2020). This way, it is desirable as soon as possible to efficiently learn a second language, correct vision through glasses or adapt to deafness and blindness since the brain conserves its plastic ability for the whole life in the prefrontal cortex, but it's harder to compensate later than in sensitive periods (Dehaene, 2020).

1.3.2. The Four Pillars of Learning

During its evolution, the brain develops four main functions that optimize the environment's extrapolation of information. These functions are called the four pillars of learning by Dehaene, which are attention, active involvement (curiosity), error feedback, and consolidation (Dehaene, 2020).

1.3.2.1. *Attention*

Selecting the relevant information is peculiar to successful learning. Attention is essential and must be properly activated to achieve effective learning (Olney et al., 2015).

Teachers and coaches must be able to capture and canalize a child's attention at every moment to improve it. Attention is composed of three systems: alerting, orienting, and executive control (Callejas et al., 2005).

Alerting is the first attention system that an organism responds to and adverts when attention is needed, modifying the person's vigilance. For example, an intense emotion mobilizes the subcortical knots, which increases reactivity and vigilance of the cortex, and a massive release of serotonin, acetylcholine, and dopamine occurs. The discharge of alert systems can affect brain plasticity. Alerting and motivation are governed by the same cerebral circuits, and intense emotions, traumas, or exposure to violent content (i.e. video games) stimulate these circuits. A competent teacher or instructor who involves his/her students or players is a powerful signal of active brain plasticity (Al-Shargie et al., 2019).

The orienting notices what the person must focus on and chooses what stimulus is relevant to them (Callejas et al., 2005). Experiments about magicians that can focus the attention of the spectators on or videos in which a figure appears or there is a change of scenography when the spectator's attention is focused on what is happening in the video are common. When a teacher teaches, he/she usually thinks that what is viewable for him/her is viewable for all, but a student probably cannot see what the teacher is trying to show him/her. If a student knows what he/she must focus on, he/she can learn (Dehaene, 2020). At the same time, an instructor training his/her players sometimes fails to capture the attention of what the players have to observe to learn technical skills. The ability of the teacher/instructor to focus attention on a topic is peculiar to modifying the brain plasticity to generate learning since attention modifies brain activity. In first grade, a child learning to read must not focus on the entire word, but he/she has to concentrate on the alphabetical code, orienting the brain activity on the specific circuit because he/she has to know the structure of the word. Learning the phonetic alphabet (which associates the letter with the sound) lets the student learn to read, activating the proper circuit. The learning is facilitated when the child follows the letter with his/her finger and gazes from the left to the right. Effective teaching can

be reached when the teacher can focus the child's attention on a specific level (Dehaene, 2020). During rugby training in which the tackle skill has to be learnt, the instructor should guide the players to the observation of the key factors which the skill is composed of (legs bent, back straight, hands at the height of the hips, the same shoulder of the forward leg, head on the external side of the opposite on the glutes, lock the hips of the opposite pulling with the hands and pushing with the legs and shoulders) and propose properly exercise to decompose the skill and learn it step by step.

Executive control is composed of a complex mental process in the prefrontal cortex that allows one to choose an action plan and determine how the information is elaborated (Callejas et al., 2005).

Executive control is strictly linked to working memory. Following a mental algorithm and controlling the execution subtends the ability to have precise remembrance. The brain uses a "temporary memory" that collects this temporary information. Automaticity is the only way to manage two different tasks at the same time. Learning requires a scale of priorities; distractions limit or nullify the effort (Mansouri et al., 2015).

Every pedagogical relationship requires a strong connection between student and teacher. The effective teacher builds a mental model, competences, and errors his/her students and makes an effort to allow them to progress. Every healthy relationship between teacher and student requires attention, listening, respect, and trust (Dehaene, 2020).

1.3.2.2. *Active Involvement*

A passive student cannot learn effectively. To reach effective learning, students have to get involved, explore, generate new hypotheses, risk making mistakes, have a clear idea of what the objective is, and share the objective. At the beginning of rugby training, a swimming lesson or a Physical Education lesson, it is important that the instructor/teacher shows the topics and the aims of the training/lesson. The active student transforms the information into words or thoughts he can understand during the learning process. Curiosity is key to learning since discovering new information and knowledge activates the dopamine reward circuit. The school has the important role of "keeping the flame of curiosity burning" (Dehaene, 2020). In rugby, a situational sport, the instructor should

provide players with questions to favour comprehension during the game and improve their decision-making ability. In swimming, instructors should ask the children questions to stimulate their self-perception and make them better organized for their movement in the aquatic environment. Using the learner-initiated style by Mosston and Ashworth can improve children's planning ability and entrepreneurial skills (Mosston & Ashworth, 2008). Schools must provide adequate stimuli for children's intelligence, both for the more receptive students through new, challenging suggestions and for the struggling ones with suitable proposals. Children must be encouraged to formulate questions, prepare presentations on what they like, and reward their initiative instead of discouraging their intervention or shutting up their questions. With the learner-designed individual program style, the learner-initiated style, and the self-teaching style, children/players are engaged in their progression since these strategies motivate their learning and creativity. The teacher does not provide solutions but encourages children to discover new topics, keeping them/attentive with questions and observation, stimulating their creativity (Dehaene, 2020). According to these considerations of guided discovery, divergent and convergent discovery should increase children's curiosity and creativity (Mosston & Ashworth, 2008).

1.3.2.3. *Feedback error*

Every error is a learning opportunity, and its direction and dimension can help the learner correct himself/herself. Providing proper or improper feedback affects the learning speed since the brain learns only when a discrepancy between predictions and outcomes occurs. Teachers/instructors should provide positive feedback and reinforcement, not focusing on the errors children/players have made but providing advice and strategies for improvement (Dehaene, 2020). Sometimes, reciprocal and self-check styles could help children be aware of their execution. Reciprocal style lets the children/players compare their execution and the model indicated by the teachers/instructors through social interaction. The self-check style requires one to perform a task and self-assess with the instruction provided by the teacher/instructor (Mosston & Ashworth, 2008).

Every area in the brain exchanges error information. When a stimulus is repeated, the brain responses decrease due to adaptation, but when a stimulus changes after the repetition of the same stimuli, the brain response is enabled again.

This condition is due to the ability to predict, and only surprising information is transmitted to the cortex. The response to the error can be faster or slower since the error is ascribable to a context or to a grammar error (“I cut the apple with the life” or “Do not forget to every day eat”). The dopamine circuit is the brain circuit in which predictive errors are better demonstrated, and the reward response is constantly anticipated.

The predictive signal is important for learning since it allows the system to criticize itself, anticipating actions’ errors and success. Predicting, detecting errors, and correcting oneself are fundamental to effective learning.

According to learning theory, the school mark is a rewarding signal but is not precise since it does not explain why the student commits a mistake and how to correct it. So, the mark is not an effective feedback error system if a detailed and constructive evaluation does not accompany it. Negative marks generate anxiety and frustration due to the error failure. Many children during Mathematics lessons feel anxiety, stress, and emotions like depression since they are convinced that whatever they do will lead them to failure (Dehaene, 2020). According to this, the inclusion style allows children/players with different abilities to participate in the same task by choosing the level of difficulty which they can perform (Mosston & Ashworth, 2008). Students with negative feelings activate brain circuits of pain and fear, and these feelings inhibit their computational ability and working memory. In order to avoid frustration due to the mark, retrieval practice should be done. A regular test maximizes the learning opportunity since distributive learning exploits the possibility of distancing learning moments. During sports practice, it is important that instructors encourage their children/players to try and not to give up despite the possible failures that occur, giving them feedback, advice, and strategies to perform their tasks properly (Dehaene, 2020).

1.3.2.4. *Consolidation*

Consolidation means developing from a more conscious and slower brain process to an unconscious and faster one through practice.

When a new task is learnt, the specific circuit is activated. Other regions, such as the prefrontal cortex or the parietal regions, are also activated with the specific circuit, reflecting the effort, attention, and conscious strategies. The massive

activation will gradually disappear with the consolidation of learning and appear only when the task is disturbed.

Routine is important to decrease the cortex's resources since the brain cannot manage two tasks simultaneously (Dehaene, 2020). According to this, command and practice styles could increase the possibility of learning by performing a precise task and repeating the same ability (Mosston & Ashworth, 2008).

Since a task is not automatized, it requires the executive attention's resources, avoiding children from focusing on another task. Sleep contributes to consolidation, which is important for children and adolescents since it affects learning.

1.3.3. Varied Practice in Preadolescents Students To Manage Executive Functions

Inhibitory control is critical for preadolescents due to the later maturation of the prefrontal cortex and the later maturation of the limbic system caused by a high level of glutamatergic neurotransmission compared to gamma-aminobutyric acid neurotransmission (Lenroot & Giedd, 2006). Impulsive behaviour and neurobehavioral excitement reflect the difficulty in inhibitory control (Arain et al., 2013). Inhibition, which is linked to perceptual-motor executive skills, is complex to manage at this stage due to an immature ability to manage cognitive control (Smith et al., 2018; Somerville et al., 2011). At this stage, the brain has an excess of synapses caused by a proliferation that leads to decreased performance and frontal activation (Blakemore & Choudhury, 2006). The relationship between motor activity and cognition can be considered to explain the relationship. Cognitive development could be enhanced by integrating cognitive tasks and motor activity in transdisciplinary learning at school. In the embodied cognition theory, the brain develops due to the actions of the body, not the cognition itself, since the sensory-motor interacts with the environment (Egger et al., 2019; Henz et al., 2018). In teaching, two approaches can be proposed: linear and non-linear pedagogy, which seem to be in contrast to each other, but they can be compared when linear pedagogy is based on variations. In linear pedagogy, the variations are based on

motor difficulties; in non-linear pedagogy, variations are related to functional difficulties.

Contextual interference is also a common aspect of the two approaches. It consists of the interaction of different combined motor abilities based on varied practice causing motor disturbance situations. The interference and varied practice induce the continuous redefinition of the motor programs and kinesthetic perception of actions (Henz et al., 2018). Cognitive functions can be improved by the active involvement of the students through reflection (reproductive styles, following a linear approach) and guided discovery (productive styles, in a non-linear approach). A varied approach lets learners increase in managing inhibitory control more than a constant linear practice since the contextual interference, with different proposals, allows a greater motor program elaboration and stimulation of executive functions (Invernizzi et al., 2022). The reflexive approach, which is used in non-linear pedagogy and varied practice, guarantees metacognitive process involvement and increased self-awareness (Bransford et al., 2000). Combining reflection and pondering with varied practice, which stimulates proficiency and creativity, can increase the learning process and improve inhibition (Zelazo, 2015).

1.3.4. Physical Education, Music and Language for a Transversal Learning

Fostering a transdisciplinary school program is one of Indicazioni Nazionali's suggestions that teachers follow. A transdisciplinary approach allows the student to develop soft skills and transversal competencies, face a problem/situation/enigma from a different point of view, study it in its globality, and learn new knowledge and competencies common to different subjects (MIUR, 2012).

Movement, music, and language are strictly related since their patterns use common neural connections: Music syntax and language syntax are processed in the same area of the brain, which is used to program movement patterns (Asano et al., 2021).

Rhythm is the main structure of music, and it is important in language for syntax, division into syllables and effective communication (Elisana et al., 2012). A good rhythmic perception helps the child to learn and comprehend the mother language rules in the first year of school (2nd and 3rd grade). Rhythm connects

people into a coral movement: It is common to observe during a concert or music event that people nod their heads or stomp the rhythm with their feet or move their bodies simultaneously (Phillips-Silver & Keller, 2012). During the 4th grade, where a lack of motor creativity in students is common, a rhythmic approach can help them learn new abilities or find new solutions to face a game situation (team sports) following a cadence (Richard et al., 2018). In the last year of middle school, a rhythmic approach can increase the involvement in P.E. classes and improve their motor coordination through the internalization of a cadence.

1.3.5. Swimming and rugby: sports practice for youth development

Sports practice is fundamental for children and youth development regarding health and proficiency. Swimming is one of the leading sports parents choose for their kids due to the healthy beliefs this activity provides. Attending swimming courses during childhood is related not only to health improvements in the muscular and cardiovascular systems (Stallman, 2017) that the activity provides but also to the safety and drowning prevention that swimming entails (Stallman, 2017). To ensure long-term activity, swimming instructors must develop social (Wiśniewska, 2016) didactical and methodological competence to ensure children in a new and quite dangerous environment (as sometimes water is perceived by the children), to vary the activity to guarantee enjoyment and self-efficacy and to avoid dropouts.

Only in the last ten years has rugby been chosen by families as one of the first sports practices for their children due to the increase and spread of the rugby movement and linked to social beliefs, such as teamwork, respect, enjoyment, discipline and sportsmanship, which this sport consists of. Rugby also engaged parents by attending matches, helping and supporting the club by washing the rugby kit or in fundraisings. Rugby's respect and sportsmanship differentiate it from the other sport. When parents and children approach rugby, it is important to educate them on the ethos of sportsmanship and rugby characteristics (Gelman et al., 2015)

Rugby is a metaphor for life, in which you can continue going forward and further with the sustainment of your mates, facing the difficulties together (tackles), leaving problems behind you (passing the ball backwards) to continue your path

and reach the goal (try). It tempers the players' character through the practice in different environmental and weather conditions. In order to avoid dropouts, instructors must have social, methodological, and didactical competencies, and they should propose a multisport practice to avoid boredom and to increase motor competence through different sports to enrich their motor baggage (Côté et al., 2007).

1.3.6. The Educational Intervention: An Empathetic Relationship

As previously mentioned, it is difficult to eradicate personal beliefs and convictions. According to the literature, teachers/instructors must acquire and improve critical reflection, must have a disposition to consider the student's needs, interests and backgrounds and have to know the social, political, and institutional contexts in which teaching and learning occur (Gomez et al., 2000). The first element on which any effective educational process is based must consider the sports instructor and teacher as an empathetic guide to be followed through their way of conducting learning and organizing psychomotor and affective conduct (Meyers et al., 2019). Educating means teaching how to live in the present time and deal with the world's reality through "living together," creating a relationship based on concrete examples, showing, organizing, pointing, and doing things together, starting from the bodily self. Movement and body experience and their ability to interact with the environment and others constitute the first step of a relationship (Froese & Fuchs, 2012; Winther, 2008). According to a System Thinking view, the leverage point is the ability to enter into a relationship with the world, referring to the ability for bodily self-organization due to mirror neurons. If this competence is not consolidated and the mirror system is compromised (as in autistic subjects), every finalized interaction becomes more complex, compromising the capacity to relate with the world (Pitti & Kuniyoshi, 2012). At the same time, interpreting a "body language" characterized by kind or aggressive interactions should be challenging. During its development, a child learns to interpret the mimics and gestures due to the relationship with the mother and activates this mirror system, which represents the basis of the relationship with others. The more the child is young, the more temporal window is activated and can be acquired as a lifespan skill. Mirror neurons identify a neuro-biological element that represents "a pitfall of nature," a kind of mirror for internalizing the other, imagining him or her,

entering his or her image within us, thanks to which we can empathically build a bond and a relationship (Arbib, 2006).

Considering the concept of system, the environment and the place of learning are affected by the general condition of the system and therefore also the exosystem (consisting of situations that can indirectly influence learning such as the type of training of teachers and sports instructors) and the macrosystem (consisting of cultural and social forces of reference such as legislative ones) represent part of the factors that can significantly affect the educational system (Côté et al., 2007). Inadequate training of instructors and teachers, inadequate empathic skills of teachers due to incorrect recruitment systems that only consider their technical skills and not their relational ones, and inadequate or missing interpretations of the rules or evidence to protect the educational process can slow down learning and the state of health, development of that organ that is the brain and that constitutes the basis of success not only in school and sports but above all in training.

An orchestra only works if it is felt that "through its music", a harmonious sonata or melody is manifested. Otherwise, an orchestral musician could know how to play an instrument very well, but if he does not connect with the other musicians, composing an engaging piece is impossible. The concept of orchestra is representative of the different systems that make up the system thinking. There is a field external to the most direct educational process involving teachers, instructors, and students, which concerns "all that world" that revolves around but can influence by accentuating or slowing down its effectiveness.

II – THE SYSTEM THINKING APPROACH

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System thinking is based on identifying a set of interconnected and interrelated elements that allow one to understand their input and contribution in optimizing an outcome (Meadows, 2008).

As an orchestra, the school educational system and the sports clubs system consist of relationships between structures. The orchestra's system comprises many families of instruments such as strings (violins, violas, cellos, basses, piano, harps), brass (trumpets, trombones, tuba, French horns), percussions (percussions, timpani), woodwind (flutes, clarinets, oboes, bassoons). It is only through the mutual relationships between these instruments that the functioning of the orchestra can be ensured during every phase of the concert since each family can express, according to the conductors at different times of the sonata or symphony, in relationship with the same family of instruments or other. School and sports clubs' system comprises the environment/facilities and fields, the local area, the social context in which they are placed, the students/players, teachers/coaches, school management/sports management, ..., which interact and influence the educational and sports process of the child and the institutions themselves. Every element of the system (the developing children, parents, sports instructors, teachers, the context, the methods, didactics, and learnings) constitutes the microsystem. The relationship that can be developed through each part of the microsystem constitutes the mesosystem. The situation which affects the relationship that emerged from the mesosystem is the instructor's and teachers' training, which establishes the exosystem. The laws which impact the entire system constitute the macrosystem.

To understand system thinking, we must delve into the relationship between the parts and the whole to grasp its overall functioning fully. This understanding helps us avoid the common mistake of oversimplifying and attributing the success or failure of a phenomenon to a single independent variable or cause. Considering the effects of mediators and moderators allows us to provide evidence of the relationship that can influence teaching, methodology, enjoyment, self-efficacy and competence (from a proficiency and creativity perspective).

A plan that interprets the interaction between the parts and their mutual recursive processes ensures an understanding of a system. This is possible by following the hologram and multidimensional complex principle, where the part is the whole and the whole is the part (Morin, 2000).

The feedback analysis of the relationships between the elements of a system and the dialogic principle (based on the dual perspective that the educator must take in observing the effects of actions taken from his or her point of view but also from that of the educated subject), allows us to ascertain how each part affects the whole to realize a function based on interactions and exchanges. For example, referring to our system in the sports context, the changes in Article 33 of the Italian Constitution (macrosystem) affect sports societies which have to invest in instructors' educational training (exosystem) to satisfy the request of the law (Parlamento Italiano, 2023), to guarantee sustainability in terms of social reporting, to improve instructors social, didactical and methodological competences and their relationship with the children (mesosystem) to encourage the development of the child (microsystem) assuring enjoyment and self-efficacy.

Using the concepts of mediation and statistical moderation helps integrate the unity between scientific evidence and the complexity inherent in human educational phenomena, such as those specific to physical education and sports (Lubans et al., 2008; Sterman, 2006).

In the core of these projects, two frameworks are developed to study how school physical education and sports club training can contribute to the overall educational training system by identifying some of its elements and outcome relationships. According to these premises, in this chapter, the preliminary studies will not be considered.

Specifically, in the two projects (Tab.1, 2 and 3), the following are included:

- individuals involved in specific roles and their relationships (in microsystem, physical education teachers or sports instructors and children and their relationships)
- school or sports success and the relationships to educational success (mesosystem)
- the relationships between the teaching approach, teaching methodologies used, and physical-motor and psycho-affective effects (mesosystem)

- the relationships emerging from the material used and the measurements made (teachers and instructors training provided by the University) (exosystem)
- the relationship between the role of the scientific evidence and the educational process (the role of mediators as enjoyment, self-efficacy and the moderators such as methodological and didactical competencies of instructors) (exosystem)
- the relationships characterizing a new interpretation related to the specificity of the contexts (modification of art. 33 of the Italian Constitution and the Indicazioni Nazionali) (macrosystem)(Parlamento Italiano, 2023).

These elements interact through reciprocal relationships: teachers and sports instructors teach children; the result of teaching depends on the training of teachers/instructors and their teaching-methodological approach; teachers and instructors depend on the organization/context in which they are placed; the school and sports club depend on statutes, ministerial regulations, and laws; and the results and their interpretation depend on the types of statistical analysis (based on mediators and moderators analysis) carried out and the measurements made (Ovens et al., 2013).

Table 1. Elements, relationships, and properties emerging from study one - "The thinking system" in a new school concept: A rhythmic teaching approach in physical education to develop creativity

Elements	Relationships	Properties emerging from relationships
PE teachers and children	Teachers teaching children	Effective teaching
School structure	Teachers are employed in a musical oriented school	They affect the musical address
Regulations	The school follows the school regulations MIUR - National	National indications determine the need for transversality and

	Indications for the curriculum of kindergarten and the first cycle of education. 2012 Annals of public education	dialogue between disciplines
School and educational success	Based on a transdisciplinary intervention	Determines specific improvement of children's motor and musical skills and general improvement of their ideational-creative ability
Methodological intervention	Based on the integrated rhythmic motor approach	Determines improvement in psycho-motor and affective behaviours
Measures approach, multi-factor analysis	Based on comparisons and interactions of direct and indirect mediating and moderating variables	Determines, in addition to a clear idea of the positive effects of a rhythmic-motor intervention in school settings, a clear relationship of how different elements interact with each other

The second project's implementation further deepens the concept of "system thinking" by distinguishing a first approach based on an "educational diagnosis" of the reality to which the project is applied from a second approach intended to treat

"specific symptoms" in order to achieve the best possible result in terms of teaching about the context (Pritchett, 2015).

Poor teacher training and poor learning outcomes are all symptoms of an educational system with poor success and performance.

Table 2. Analysis of the "symptoms" of the Sport Education System in Rugby (study two - part one) - Relationship between multi-teaching styles and didactics effectiveness on rugby instructors and minirugby players

Symptoms	Cause or determinant of possible poor outcomes in athletic and educational success	Corrective intervention
Poor teaching skills of instructors	Problems in communication, student engagement, personal competence	Learn to use supportive communication, appropriate use of nonverbal and paraverbal communication. Focus on active teaching styles in which learners are protagonists
Poor methodological capacity of instructors	Prevalent and almost exclusive use of command and practice styles	Learning to use a multiteaching approach, based on providing questions and approaches that force teachers to use different types of interaction
Poor ability of instructors to interact with students and	Unilateral technical-sport specialization	Learning to use a multisport approach by understanding the relationships between

stimulate alternative motor- sport practice		specific practice and multilateral practice
Instructors' organizational and lesson management problems	During the phases of the lesson in which children are not physical involved in motor activity (e.g., in explanations or distribution organization of material) leaving learners standing still	Make students sit down to avoiding unnecessary movements that are distracting them, resulting in little concentration on lesson topics
Poor coordination and transference skills in pupils' play	Unilateral motor practice	Proposed multisport and multilateral approach. Greater use of teaching styles that enable learners' decision-making processes
Psychological effects of the proposal on children	Empathic skills and self- control of instructors	Proposals direct to gain awareness of how learning teaching skills and especially methodological skills adaptable to different contexts can result in improved affective experiences of children

Table 3. Elements, relationships, properties emerging from study two (part two) - Integrated multisport training for rugby instructors: project success and effects on mini-rugby players

Elements	Relationships	Emerging properties of relationships
Rugby instructors trained in multiteaching/ multisport approach and children	Instructors teach children	Have effective teaching
The sport structure	Instructors employed in a sports facility with integrated multi-sports approach	They affect specific motor practice by determining general greater ability to play and improve motor competence
The regulations	Constitutional Law 2023, No. 1 determined changes to Article 33 of the Italian Constitution	A relationship between sports and educational processes is determined by affirming the value of sports and sports associations as educational centres
Sporting and educational success	Based on an intervention not primarily focused on sports performance but primarily on varied skills useful for personal growth	It determines a specific improvement in the playing competence and general Physical literacy of children

The methodological intervention	Based on integrated multisport, multiteaching and need supportive communication teaching approach	It determines an improvement in psycho-motor and affective conducts in children.
The measures approach, analysis of multiple factors	Based on comparisons and interactions of direct and indirect variables of mediation and moderation	Determines, in addition to a clear idea of the positive effects of an integrated multi-sport intervention in rugby a clear relationship of how different elements interact with each other

The three tables evidenced the relationship between the scientific outcomes (related to the academic community) and the practice (community of practice) (World Health Organization, 2022).

In order to apply System Thinking to a School Concept or a Sports Context, it is necessary to consider the following:

A. The ideas and contextual features that evidence the need for a comprehensive and interactive view of the elements that distinguish a specific reality (simulation studies of reality to verify and predict scientific and application feasibility)

- a. The specific context of the music-oriented school and the concept of employing a transdisciplinary rhythmic-motor approach, with the potential to enhance children and young people's attention and listening skills, thereby fostering an engagement with the choices and needs of a specific reality in the artistic-creative-musical sphere

- b. Verify, through a feasibility test (study two-phase one), whether the particular context of the sports club, with specific reference to the rugby instructors of the youth sector, is appropriate for the use of sport as an educational medium
- c. Considering the results and weaknesses that emerged from phase one of study two, verify whether a multi-sport instructor training, integrated with didactic-methodological skills, could constitute a type of training that could be placed alongside the traditional specialized training of the Italian rugby federation

B. The set of analysis procedures for interpreting data considering multiple integrated variables (dependent and independent variables related to mediators and moderators' analysis and multiple correlations between elements)

- a. In study one: tests assessing the perception of rhythmic skills; tests assessing motor creativity; questionnaires assessing children's enjoyment and self-perception following the proposed lessons; IFITS and SOFIT video analysis to identify the type and diversification of teaching used by the teacher and the physical-motor involvement of the students
- b. In study two (phase one), a comprehensive set of analysis procedures was implemented. The analysis included evaluation tests of the instructor group's teaching competence during the placements with detection of results on special forms, evaluation tests of their methodological competence with proposed completion of a questionnaire regarding the teaching styles used, and two video analysis procedures (IFITS and SOFIT) for further verification of the teaching styles used and the interaction with the learners. Additionally, two questionnaires were used to assess empathic and self-control skills. For the children's group - tests to assess motor competence, tests to assess play ability, questionnaires to assess enjoyment and self-efficacy following the proposed lessons, and questionnaires to assess the level of physical activity performed
- c. In study two (phase two), the same set of procedures as in phase one is applied. In the extra instructor group, a questionnaire was proposed to check satisfaction related to the instructor course, and questionnaires

related to empathy and self-control were not proposed because they were considered qualities that could be developed over longer intervention times and were inherent in personal skills that could be modified only partially

C. The points in the system where a small intervention can bring about substantial changes (leverage points and facilitators such as rhythmic approach to determine creativity and multisport training course approach that enable practical accessibility and transferability of scientific evidence)

a. In study one, the leverage point that enabled the instructional effectiveness of the proposal was the cross-cutting between physical education and music education

b. In study two (phase two), the leverage point that allowed for the didactic effectiveness of the proposal is the integration of phase one, aimed at investigating the weaknesses of a single-discipline rugby sports system, with phase two, characterized by multisport instructor training integrated with didactic-methodological skills, constituting an outcome feasibility test

D. Institutional culture and the barriers (silos) that must be provided in the system under consideration (inadequate teachers and instructors training)

a. In study one, poor didactic-methodological competence of teachers and a contextual reality that is rigid, not very open to educational success, disinclined to embrace ministerial indications of cross-curricular between disciplines, predominantly focused on mono-disciplinary academic success

b. In study two (phase one), a mono-disciplinary view of sport with little knowledge of the indications related to Article 33 of the Italian Constitution and thus directed more to sporting success, understood as performance, than to educational success based on a comprehensive formation of individuals. The poor didactic-methodological skills of the instructors, which are essential to enhance and actively involve children, make them protagonists in their learning and training

E. The nonlinear relationship between instruction/teaching and learning effects (where the dynamic interaction between multiple elements, such as

personal competencies like empathy, self-control and psychological involvement, always determines the outcome)

- a. In study one, the interaction between joy and motor creativity highlights how a competent teacher determines enthusiasm involvement, but also the contribution of musical art and bodily expressiveness are all key elements, dynamically integrated and interdependent, in fostering specific outcomes and learning effects in this particular context
- b. In study two (phase two), the interaction between the variables characterizing the approach and the teacher's teaching-methodological decisions in the specific multisport or single-sport context determine different responses to the interactions related to children's psychomotor and psychological variables

F. The closed chain of causal connections needs to be predicted and selected (after careful analysis of the literature) by placing them within the boundaries of the system (the results in terms of sports performance and school performance).

- a. In study one: the relationships between teaching types/styles and motor creativity; the relationships between joy and motor creativity; the relationships between motor creativity and self-perception
- b. In study two (phase two): the relationship between sports models (multisport and single-sport) of teaching and educational success; the relationships between teaching styles and educational success; the relationships between teaching-communication skills and educational success

G. The possible lagged effects due to fluctuations and instabilities in the system are determined by the relationships between different variables that interact and evolve mutually (empathy and self-control were not analyzed since these variables need longer terms to be developed and the retention of the abilities of multidisciplinary approach and multisport approach with a crossover study)

- a. In study one: possible lagged effects, not found in this study due to the short time of analysis but evident in the literature, are those highlighted by the relationship between rhythmic-motor competence, enjoyment, self-perception
- b. In study two (phase one): Questionnaires related to empathy and self-control were proposed only in this phase because qualities considered to be developable over a more extended period of intervention and inherent in personal skills that can be modified only partially; an analysis of a more extended period of intervention, due to the fluctuation in the interaction of the different variables, might result in different effects than the results of the feasibility test (phase two)

H. The unintended consequences (due to a complex system)

- a. Study one: Contrary to literature evidence, the predominant use of reproductive styles, as part of a rhythmic-motor approach, was found to be the most effective in achieving motor creativity goals in children and youth
- b. In study two (phase one): the unclear specific relationship between instructors' self-control ability and effects on self-efficacy and enjoyment of their learners, which could fluctuate each time depending on the characteristics of the proposal, learners and context (phase one).

III – PRESENTATION OF THE FIVE SCIENTIFIC PAPERS: THE STRUCTURE OF THE STUDIES

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The research, which was developed through collaboration between the University of Milan and the Catholic University of Murcia, was structured through 5 studies, all already published (Appendix 4). The concerned System Thinking approach is applied to the School (elementary and middle school) and Sports System (swimming and rugby). The characteristics of the five studies are summarized in Table 4 at the end of the chapter.

3.1. PRELIMINARY STUDIES

3.1.1. Aquatic Physical Literacy: The Effectiveness of Applied Pedagogy on Parents' and Children's Perceptions of Aquatic Motor Competence

The first manuscript (Study A), Aquatic Physical Literacy: The Effectiveness of Applied Pedagogy on Parents' and Children's Perceptions of Aquatic Motor Competence, was published in October 2021 in the International Journal of Environmental Research and Public Health and it is the first preliminary study about the System Thinking concept which analyses the microsystem and the mesosystem in the sports environment with a qualitative and quantitative approach.

The study's context is the swimming school environment with five-year-old children. In the study, linear and nonlinear approaches were compared. The relationship between the children and instructors, instructors and parents, Children and parents, and methods and learnings were analyzed (micro and mesosystem).

The results revealed an interest in both motor and psychological aspects.

3.1.2. Effects of Varied Practice Approach in Physical Education Teaching on Inhibitory Control and Reaction Time in Preadolescents

The second manuscript (Study B), Effects of Varied Practice Approach in Physical Education Teaching on Inhibitory Control and Reaction Time in Preadolescents, was published on Sustainability in April 2022. It is the second preliminary study about the System Thinking concept, which analyses the micro and mesosystems in the school environment with a quantitative approach.

The study was conducted in the middle school with a group of preadolescents. Three teaching methods were compared: a constant linear pedagogy approach, a linear pedagogy approach combined to varied practice, and a non-linear approach. The relationship between teachers and preadolescents and methods and learning were investigated (micro and mesosystems). The results that emerged are interesting for both motor and cognitive aspects.

3.2. SYSTEM THINKING STUDIES

These studies aimed at incorporating the exosystem and macrosystem, using statistical procedures as moderators and mediators, which allowed them to grasp the circular relationships between the different variables.

3.2.1. The “Thinking system” in a new school concept: A rhythmic teaching approach in physical education to develop creativity

The third manuscript, and the first related to System Thinking, The “Thinking System” In A New School Concept: A Rhythmic Teaching Approach In Physical Education To Develop Creativity, was published on Plos One in March 2024. It incorporates the exo and macrosystems.

It was conducted in elementary and middle school, comparing rhythmic and traditional approaches. The relationships between children and teachers and methods and learning were investigated. The results were related to motor, psychological, and musical aspects. Using a quantitative approach, the role of mediators and moderators and the transferability of the effects considering the Scholastic Law that impacts the School System (exosystem and macrosystem) were investigated.

3.2.2. Relationship Between Multi-Teaching Styles and Didactics Effectiveness on Rugby Instructors and Minirugby Players

The fourth study and the second on System Thinking, Relationship Between Multi-Teaching Styles and Didactics Effectiveness on Rugby Instructors and Minirugby Players, was published on Children in October 2024 and it incorporated the exo and macrosystems. It was conducted in a rugby sports society context where multi-teaching and non-multi-teaching approaches and the relationships with the didactics' competence were compared. The relationship between instructors and children, methods and learnings and didactics and learnings were investigated. The results showed effects on motor, cognitive, and psychological aspects. Using a quantitative approach, the role of mediators and moderators and the transferability of the effects considering the changes in Article 33 of the Italian Constitution were investigated. These modifications impact the Sports System since it assumes the role of an educational institution (exosystem and macrosystem).

3.2.3. Multisport-Integrated Training for Rugby Instructors: Success and Effects on Minirugby Players

The fifth study, and the third about System Thinking, Multisport-Integrated Training for Rugby Instructors: Success and Effects on Minirugby Players was published in the Journal of Functional Morphology and Kinesiology in December 2024.

It was conducted in a rugby sports society context and aimed at comparing reproductive and productive teaching styles and didactical competences. This approach was suggested by the results of the previous study, which showed a poor use of productive teaching styles with negative effects on children's competences. According to the previous results, a multisport teaching styles course was provided.

Table 4. *Synthesis of the characteristics of the studies (part 1)*

Title	Aims	Theoretical framework	Key Elements
Aquatic Physical Literacy: the effectiveness of Applied Pedagogy on parents' and children's perception of aquatic motor competence	To compare the effects of a teacher centered approach (linear pedagogy) and a student-centered approach (non-linear pedagogy) on motor skill acquisition and children's and parent's perception of swimming	Non-linear pedagogy	Children showed a preference for the nonlinear approach, finding it more engaging whereas the linear program led to greater progress ($p<0.05$, $\phi=0.08$) and was deemed more rewarding by parents
Effects of varied practice approach in physical education teaching on inhibitory control and reaction time in preadolescents	To investigate the effects of non-linear and linear varied practice compared to a constant linear practice on inhibitory control and reaction time (capacities that involve cognition in preadolescents)	Varied practice Non-linear pedagogy	Varied practice (non-linear and linear) induces larger improvements than linear constant practice in inhibitory control ($p<0.05$). Varied linear practice seems to be the most effective approach aimed to improve cognition within physical classes in preadolescents
The "Thinking System" in a new school concept: a rhythmic teaching approach in physical education to develop creativity	To compare the effect of rhythm-based activity and traditional activity on motor creativity and recognizing rhythms; verify how the psychological aspect and rhythmic approach influence each other and are related to age.	Rhythmic teaching approach, multi-teaching styles	Rhythmic teaching directly affected motor creativity ($p=0.001$) and rhythmic perception capacity ($p=0.002$). The rhythmic methodology proposed by specific multi-teaching styles involves children in an enjoyable activity with more moderate to vigorous physical activity
Relationship between multi-teaching styles and didactics effectiveness on rugby instructors and minirugby players	To evaluate the correlation between rugby instructors' methodological and didactical competencies and compare them with children's motor competence and psychological aspects	Multi-teaching styles, didactical and personal competences of instructors	The group of instructors who used more teaching styles showed a positive correlation with didactical-communicative competencies ($\rho=0.661$, $p<0.001$). The group of instructors who used more teaching styles shows a strong correlation between motor competence and the psychological aspects of the children analyzed ($\rho=0.741$, $p<0.001$). Empathy and self-control of instructors correlate with the psychological aspects of children
Multisport integrated training for rugby	To compare the effects of a multisport pedagogical integrated	Multisport, multi-	The multisport integrated course model outperformed the

instructors: success and effects on minirugby players	course on minirugby instructors' teaching competence and children's players motor conduct.	teaching styles, teaching competence	traditional mono-sport group in motor competence ($p<0.05$) of children. Children's psychological aspects acted as mediator that amplified the effects of multisport training course ($E=3.69$ $p<0.0028$ and $E=3.04$ $p<0.019$). The instructor's didactical and methodological competences were moderators directly favoring ($E=8.05$ $p=0.002$; $E=17.5$ $p=0.001$) or worsening ($E=4.76$ $p=0.053$; $E=13.42$ $p<0.001$) children's motor competence
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Table 5. *Synthesis of the characteristics of the studies (part 2)*

Population	Type of intervention	Study design	Presence of comparison group	To be learned skills	Measurement instrument	Intervention duration	Micro- and meso-system	Exo- and macro-system
Number n=100 (F=53, M=47) Age 5.9 (± 0.3) years old	Non linear pedagogy	Pretest Intervention Post test	Yes (linear pedagogy vs non linear pedagogy)	Acquatic skills Perceived aquatic skills	Perceived progress observed by experts. Questionnaires	Number of sessions n=30 Duration of each session= t=50 minutes Total duration t=15 weeks	yes	no
Number n=83 (F=30, M=53) Age 13.2 (± 0.3) years old	Varied practice Non linear pedagogy	Pretest Intervention Post test	Yes (linear costant practice vs non linear pedagogy and varied practice)	Cognitive skills; (executive functions and reaction time)	Clinical reaction time Clinical selective attention and inhibitory control Video analysis of lessons	Number of sessions n=24 Duration of one session t=60 minutes Total duration t=12 weeks	yes	no
Number n=76 (F=40, M=36) Age 8.9 (± 2.1) years old	Rhythmic teaching	Pretest Intervention Post test	Yes(rhythmic teaching vs traditional teaching)	Motor creativity and recognizing rhythms; psychological aspects	Perceived progress observed by expert. Questionnaires Video analysis of lessons	Number of sessions n=8 Duration of one session t=60 minutes Total duration t=8 weeks	yes	yes
Number children n=220 (F=4, M=216) Age 9.6 (± 1.1) years old	Teaching styles and didactical communicative competencies	Evaluation of effectiveness of instructors' competencies	Yes (multiteaching vs non multiteaching styles)	Motor competencies; psychological aspects	Video analysis of lessons. Questionnaires. Perceived competences observed by expert	Number of sessions n=12 Duration of one sessions t=120 minutes Total duration	yes	yes

Instructors n=50 (F=5, M=45) Age 39 (± 13.6) years old							t=4.5 weeks	
Number children n=220 (F=4, M=216) Age 9.6 (± 1.1) years old Instructors number n=50 (F=50, M=45) Age 39 (± 13.6) years old Teaching experience 6.0 (± 5.7) years	Multisport integrated pedagogical course model	Pretest Intervention Post test	Yes (multisport integrated pedagogical model vs mono-sport)	Children's motor competencies; psychological aspects Performance Instructors' didactical competencies; methodological (multi teaching styles) competencies	Video analysis of lessons. Questionnaires. Perceived competences observed by expert Internship evaluation sheet	Number of children's sessions n=52 Duration of one sessions t=120 minutes Total duration t=26 weeks Number of Instructors' course training sessions n= 4 Duration of one sessions t=6 hours 15 minutes Total duration t=6 month	yes	yes

IV – SCIENTIFIC PAPERS

IV -SCIENTIFIC PAPERS

4.1. AQUATIC PHYSICAL LITERACY: THE EFFECTIVENESS OF APPLIED PEDAGOGY ON PARENTS' AND CHILDREN'S PERCEPTION OF AQUATIC MOTOR COMPETENCE

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4.1.1. Abstract

Goal of swimming school during early school age is to promote physical literacy. According to linear or non-linear pedagogy a linear or non-linear approach teaching style can be used. Aim of our study was to investigate whether a different teaching methodology, as using a teacher-centered approach (linear pedagogy), or a student-centered approach (non-linear pedagogy), could differently influence the perceptions of aquatic activity of children and parents. Parents of 100 children (53 females and 47 males, age 5.9 ± 0.3 years old) participating to the study were previously interviewed to ascertain their expectations regarding the swimming course. Participants were in a medium-high social context. Subsequently, considering the data of the incoming aquatic motor competence's tests, children were divided into a linear (LI) and non-linear (NL) pedagogy group. A total of 4 instructors were enrolled. Upon completing the swimming course, the aquatic motor competence's test was repeated, a pictorial scale of perceived motor competence was administered, and a questionnaire regarding the course was proposed to children's parents. Physical development and learn to swim resulted two of the most important reasons leading parents to choose swimming courses. LI reached greater progresses than the NL in actual motor competence (A.M.C.), while NL perceived a higher aquatic motor competence (P.M.C.) in 7 out of 10 items of the pictorial scale. Parents of children in LI, gave greater importance to the teacher's role, while NL's parents pointed the acquisition of children's abilities as pivotal. In conclusion, NL approach was more appreciated by children, while LI method was more rewarding for parents because initial expectations were satisfied.

Keywords: Grounded theory; swimming; Linear Pedagogy; Non-Linear pedagogy

4.1.2. Introduction

The acquisition of good health practices, the awareness of the benefits of physical activity and the acquisition of motor skills are the basis for the development of appropriate motor literature leading to the maintenance of healthy behavior throughout life. Physical literacy can be described as the potential which everyone has in terms of motivation, confidence, physical competence, knowledge and understanding to assess and assume the responsibility for maintaining goals of physical activity throughout their lives.

Whether this potential is expressed or not, depends on the motor competence, the actual physical activity carried out and the cultural context (Whitehead, 2013). In this regard, each child needs to perform an adequate quantity of physical activity level in order to achieve the proficiency barrier, related to the adequate physical activity levels for health (De Meester et al., 2018).

Water physical activity is a means for cognitive and motor development: practical and senso-motor intelligence constitutes the basis for the development of verbal and cognitive intelligence. It can be asserted that there's a continuity between intelligence and biological process of adaptations to the environment (Piaget & Cook, 1952; Stallman, 2017).

Through water practice, neuropsychic development of language (Kliorin & Aleksandrovich, 1989; Stallman, 2017) and children's personality are promoted (Diem, 1982; Mæland, 1992) which can be used in socio-relational sphere.

Early approach to aquatic environment allows an individual to get related with the outside environment with greater autonomy, decision-making independence and willing. These skills made the child able to develop more self-confidence and promote the overcoming of fear which could hinder the possibility to face new and unknown situations calmly (Diem, 1982)

In addition to psychosocial and cognitive development, swimming allows the development of strength, balance, flexibility, during the pre-scholar age (Howells & Jarman, 2016), and the improvement of cardiovascular adaptation leading to greater heart efficiency (Costa et al., 2016). Swimming is therefore a useful skill for life and can promote the health status of an individual since a very young age.

The basis for learning aquatic motor competence are the development of movement, breathing and balancing techniques; altogether they constitute the bases for the safeness and comfort of an individual in the aquatic environment (Stallman, 2017).

Balance in water is a skill to be acquired early because learning roll and body alignment, which promote a good shoulder-shaped balance and reduce water resistance during moving, are more complex to internalize in adulthood (Howells & Jarman, 2016).

Respecting the stages in learning the swimming skills is very important: children until 5 years old need a long period of psychological adaptation to the aquatic environment before being able to move with confidence and acquire specific skills (Torlakovic et al., 2018). Interaction with the peers and the teacher will allow the development of languages and social skills as they become more self-confident. According to the social constructivism theory (Tran, 2013; Vygotsky & Cole, 1978), cooperative learning in small groups facilitates the learning through the observation of the peers. Likewise, also swimming instructor's social competences are fundamental to establish a relationship within the group (Wiśniewska, 2016). Social competences could stimulate both children attention and curiosity, through an active involvement, and identify what the children already knows and what it is necessary that she/he learns. This process needs the teacher's observation (Langendorfer, 2012; Vasquez, 2011) and the consequent supply of appropriate feedbacks to consolidate what has been previously learnt.

In this context the teacher's role is more or less evident depending on the methodological approach that is used: " It is not sure which is the best teaching method, but it is clear that the most efficient program is one that respect each characteristic of the child, which are unique " (Vasquez, 2011). The goal of the swimming school during early school age is to promote physical literacy (Whitehead, 2013). In this respect, the choice of the teaching style to adopt could be directed towards a linear approach (linear pedagogy) (Lee et al., 2014). With this method the instructor-facilitator proposes different activities based on imitative approach. This criterion is peculiar of reproductive styles, in which are determined a transfer of information as in the cognitivist approach (Invernizzi et al., 2019), through the active interaction and the collaboration with the learner. Alternatively the approach can also be non-linear (non-linear pedagogy) (Lee et al., 2014). It is an

ecological-dynamic method based on productive styles in which the facilitator prepares the material in order to create new situations and intervenes when is occurred, without providing instructions to the group. Motor creativity and students' autonomy are stimulated by the environment (Raposo et al., 2020) This allows the child to express himself freely and at the same time to address her/him towards a new motor representation of her/his body related to an environment which requires an important adaptation to the terrestrial motricity.

Even though there is no one teaching style better than another (Vasquez, 2011), we find it interesting to consider and investigate parents' and children's perceptions about their acquired competences through the use of the two teaching styles. Our researching field regards the scope of physical literacy and personal autonomy, the relationship between child and aquatic environment and the impact of the figure of the instructor both from a psychosocial and an organizational point of view. Starting from the survey concerning to the aquatic motor culture of the parent, the aim of our study was to investigate whether a different teaching methodology may influence, in a different way, the perceptions of aquatic activity of children and parents.

4.1.3. Materials and Methods

4.1.3.1. *Participants and context*

A total of 100 children (age 5.9 ± 0.3 years old), 53 females and 47 males of a medium-high social context, with their parents, participated to the study for fifteen weeks, by organizing the activity into two weekly lessons of 50 minutes duration each. A total of four instructors were involved in the study, two for the linear pedagogy group (LI) and two for the non-linear pedagogy group (NL). During lessons instructor/children ratio was 1/8.

Eight children were excluded from the study due to their incomplete enrolment in the course, 5 for LI group and 3 for NL group.

To be included in the trial, children had to be 5-6 years old. Conversely, having previous swimming experience or having cognitive or motor disorders were considered as exclusion criteria.

An informed consent was signed by the parents before participating to the study and the trial was approved by the Ethics Committee of the University of Milan (protocol code 2/12).

4.1.3.2. *Procedure*

The parents of the children who participate to the study were interviewed in advance with the aim to express their expectations regarding the swimming course.

After the interview, children were divided into two groups considering the data of the incoming aquatic motor tests in order to obtain two groups with equal aquatic motor competence.

Linear pedagogy group (LI) was composed by 50 children, 23 females and 27 males (height 116 ± 6 cm; weight $22,7 \pm 4,1$ kg; Body Mass Index (BMI) $16,8 \pm 2,3$ kg/m²), the non-linear (NL) one was composed by 50 children, 30 females and 20 males (height 116 ± 6 cm; weight $21,4 \pm 3,5$; BMI $15,9 \pm 1,4$ kg/m²).

The groups were homogeneous at the baseline for the value of Langerdorfer-Bruya (Langendorfer, 2012) actual motor competence test.

LI group and NL group were involved in a period of swimming learning using linear and non-linear teaching styles respectively (Table 6), and at the end they were subjected to the aquatic motor tests again to verify which group had more benefits concerning actual motor competence. The two groups performed the lessons in pools with similar characteristics (shallow water; water temperature = 30°C; environment temperature = 25°C). Subsequently, the parents of the children in both groups responded a multiple-choice questionnaire in order to verify the teaching style influence in parent's perception of the swimming course. To evaluate the children's self-perception at the end of their swimming course, children completed the pictorial scale of perceived aquatic competence.

Table 6. Comparison of the main methodological principles regarding teacher-centered (LI) and student-centered (NL) pedagogies

METHODOLOGICAL PRINCIPLES	
Teacher-centered pedagogy (Wilke, 2014)	Student-centered pedagogy (Pansu, 1998)

Linear pedagogy group	Non-linear pedagogy group
Specific training aimed to immersion, buoyancy and propulsion	No specific training aimed to immersion, buoyancy and propulsion
Proposals due to a physical effort of the child (muscular, cardio-respiratory)	Discovery of the aquatic environment for a own initiative and not as a result of a external imposition
Proposals aimed to promote a rapid autonomy and independence in water	Ludic interaction between children and between children and teacher
The instructor stimulates and proposes specific exercises aimed at a gradual and progressive conquest of the aquatic environment	Respect for the child, for his/her emotional reaction and learning rhythms
Use of the metaphors and imitative exercises. Gradual progression of exercises aimed at the learning of a specific operative goal at a time	Teaching aids and materials as stimuli of learning. Randomized and varied multilateral approach aimed at testing multiple motor possibilities simultaneously

4.1.3.3. *Information collectio*

4.1.3.3.1. Preliminary interview on swimming course perception through the Grounded Theory (GT)

Preliminary interview was led on the parents of the children participating to the trial and was conducted according to the Grounded Theory's model (Corbin & Strauss, 1990). This approach involves a semi-structured interview that starts from the research questions and develops through the answers and argumentation of the interviewees. Therefore, no pre-defined questions were provided, but rather a general initial question from which different questions were developed according to the answers given by the respondents. The purpose of the interview was to investigate the aquatic motor culture of the parents. After this first phase, the coding of the answers was shared. In the first step of the opened coding, the themes called as pre-labels were extrapolated, those which expressed similar concepts

were grouped in single theme defined labels. After the opened coding, the axial coding was done, dividing labels into categories, and quantifying them according to how often they appeared in the interviews. The labels appearing with a frequency less than 50% were defined as sporadic, the labels appearing with a frequency between 51% and 70% were defined as typical and the ones appearing with a frequency more than 71% were defined as generals. From these, the Core Category was extrapolated, i.e., the emergent category. The answers were grouped regardless the child belong to the LI or NL group, and before the assignment to either group.

4.1.3.3.2. Aquatic motor competence

Children were involved to aquatic motor tests to identify their initial level of actual motor competence. The same tests were repeated at the end of the course with the aim to verify the progresses achieved after the intervention. In this regard, the Langerdofer-Bruya (Langendorfer, 2012) test was used, in order to investigate the water entrance capacity, the immersion, the breathing, the buoyancy, the movement of the arms, the recovery of the arms, the movement of the legs and the arms-legs coordination. The entrance in water with different orientations and the body's inclination in water were not considered. The test was proposed by two neutral experienced researchers in this field, authors of this study, and not directly involved in the teaching.

4.1.3.3.3. Parents' Questionnaire (PQ)

After the intervention with the two teaching styles, a questionnaire with 12 multiple-choice questions was proposed to the parents, in which they had to give his/her opinion regarding the swimming course perception. The questions were structured on the basis of the answers obtained in the first interview with the grounded theory method and related to the three thematic areas emerged: physical literacy (PHY; 3 questions), child-aquatic environment relationship (CHI, 4 questions) and instructor (TEA, 5 questions). Physical literacy area regards what the swimming school teaches to the children in terms of wellness, confidence and specific competence; the children area refers to which aquatic competence the child achieves and learns from the course; the teacher area en-closes all the aspects which

can influence or promote through the teaching style adopted. Each question presented 4 possible answers of which 2 negatives and 2 positives. Finally, the answers regarding positives perceptions of the parents were grouped and compared.

4.1.3.3.4. Pictorial scale of perceived aquatic motor competence (PS)

After the intervention with the two teaching styles, a pictorial scale of perceived aquatic motor competence was proposed. The questionnaire designed by Murcia and Ruiz Perez (Moreno Murcia & Ruiz Pérez, 2008) is composed by 10 items in which it is possible providing an answer between the three choices and each option has a referred image in order to be easily understood by the children (Moreno Murcia & Ruiz Pérez, 2008). The questions referred to different scopes of aquatic motor competence also grouped in three thematic areas as the relationship with the swimming pool environment (related to aspects such as autonomy and motivation, typical goals of the physical literacy; questions 1 and 2), water competence (in which children's perception in specific aquatic motor competence and his relationship with the aquatic environment are investigated; questions 3, 4, 5, 6, 7 and 8) and psychosocial aspects related to the performance and relation with peers, (questions 9 and 10). Each response was regarded to a different level of the perception of the competence (A=high, B=medium; C=low); for the comparison made, positive answers (level A and B) were considered.

4.1.3.3.5. Attribution of colours

In order to differentiate the analysis' approach, in figure 1, 2, 3, 4, 5, we have considered three different colors (arbitrarily chosen) as Grounded Theory method suggests, for a better recognition of categories and thematic areas (Tarozzi, 2020).

In this regard we decided to allocate the dark grey to the answers related to the concept of physical literacy, the light grey to the aspects related to the personal aquatic motor competence of the child, and the white to the answers distinguishing the sphere of the teacher.

4.1.3.4. *Data Analysis*

A mixed approach with predominant-qualitative approach for this study was used, in order to combine and integrate the physical aspects, such as aquatic motor competence, and social and psychological aspects, such as parents' and children's perceptions.

4.1.3.4.1. Qualitative analysis

A qualitative analysis approach for the results of preliminary interview was led, according to Grounded Theory methodology. Furthermore, parents' questionnaire and children's perceived motor competence were administrated as explained previously.

4.1.3.4.2. Quantitative analysis

To analyze the pre-post intervention changes measured with Langerdofer-Bruya test, the non-parametric Wilcoxon test was used, while the Mann-Whitney test was used for delta comparison. For all performed analysis, was considered an $\alpha=0.05$. Then the Effect Sizes (ES) were calculated using Phi (ϕ) and r^2 . Coefficient of variation (expressed as a percentage $CV\% = (\text{Standard Deviation}/\text{Mean}) \times 100$) was calculated in order to identify the intra and intergroup homogeneity.

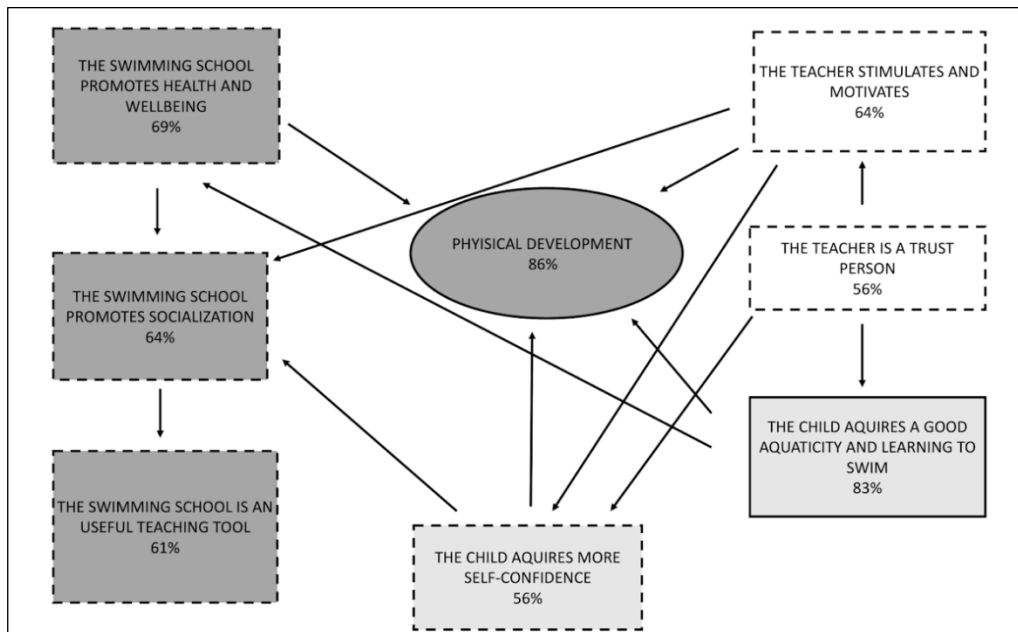
4.1.4. Results

4.1.4.1. *Qualitative and quantitative analysis*

4.1.4.1.1. Preliminary semi structured interview proposed to the parents, qualitative analysis

According to the Grounded Theory Method, results can be represented through schemes, as shown below in Fig.2. The diagram illustrates the themes that emerged from semi-structured interview set up with parents, starting from the research question.

Figure 2. Representation of the themes emerged from the semi-structured interview with parents about considerations related to swimming school and swimming course attended by the children. The core category is represented at the center, in the ellipse with the continuous edge. Rectangles with continuous edges represented the category with the most frequent labels (>75%), those with dashed edges the category with a frequency between 50% and 75%. The dark grey indicates physical literacy's dimension, the light grey stands for the children's size, and the white is associated to the instructor's sphere. The categories with a less frequent labels (<50%) were not considered in the study.



Analysis shows that **physical development** resulted one of the most important reasons that led parents to choose swimming courses (**86%**). The idea often is enforced by the pediatrician: “The doctor advised us swimming during the growing phase because is the best sport” (interview n.12), “Since my son has flat feet and is a little bit overweight, the pediatrician advised me to take him to the swimming pool” (interview n.13).

Parents considered the swimming course as a proper teaching tool because the discipline required into the aquatic environment can be conveyed through the game: “In my opinion swimming can be taught with a playful key, even though concentration is required”.

The category **acquired good water skill and learning to swim (83%)** represent the main motivation for parents to enroll their children in the pool in order to acquire

a good swimming technique: “I would like her to learn swimming very well, to become a good swimmer, which I’m not.” (interview n.34), “We started early because it’s difficult to learn, you must have a precise technique for breathing and coordination of the movements” (interview n.63). Those who acquired familiarity with water, wanted their children to follow their same example: “I wanted her to have a beautiful aquaticity since she was a child, to love water like I do.” (interview n.2), “I decided for swimming because his father is very sporty, so they can swim together” (interview n.29).

A wellbeing state and health contributes to guarantee child’s physical development regarding the physical literacy dimension, while acquiring more self-confidence constitutes the base to guarantee a good physical development of the child. Physical development is also influenced by the instructor who must be able to stimulate and motivate the child. “I hope my daughter always grows up with people which could passionate her to sport” (interview n.35), “The instructor who gratifies my daughter is a good thing” (interview n.7).

The relationship based on trust between instructor and child is decisive for the acquisition of a good aquaticity and consequently also for the physical development which happens through aquatic environment: “The child confidence in instructor is crucial” (interview n.12), “the parent feels more comfortable if he sees a good teacher” (interview n.3).

The swimming school is considered as a mean to improve and wide the possibility of promoting the socialization and relationship with the peers. Sometimes this need is encouraged by the parents: “I would like my son, through the swimming course, learning to approach with the others feeling at ease” (interview n. 24), “Learning to stay in a group and find new friends” (interview n.20) overall for the lonely and shiny children who have difficulties with social relationships: “My son is a bit lonely so they recommended us an activity with other children” (interview n.93) and sometimes this need is searched by the children themselves, who joined the swimming school because of the attendance of their friends: “He decided himself, probably because of his two school mates who already attended the swimming course, so he wanted to attend it too” (interview n.70).

4.1.4.1.2. Quantitative analysis related to actual aquatic motor competence tests of the children

Pre- and post- intra-group results of the linear group (LI) and non-linear group (NL) and inter-group (LI vs NL) results are shown in Table 7.

The pre and post comparison of LI and NL group showed that children improved overall. A more detailed analysis of the LI group showed that children improved all the skills investigated except for water entry, for which no statistically significant differences were emerged.

Within NL group appreciable improvement were encountered in competence related to buoyancy, arm propulsion action, and arm recovery action. The comparison between LI and NL showed that, the LI group reached greater progresses than the NL group, particularly in terms of buoyancy, arm propulsion action, and combined movement. NL group, on the other hand, reached greater progress in arm recovery action and in the homogeneity intragroup evaluated with CV%. Considering this last result, NL group has achieved a greater homogeneity at the end of the swimming school (CV%=12.2%) than the LI group (CV%=17.9%). In particular for “Breathe control and immersion” (CV% from 18.3% to 12.5%), “buoyancy” (CV% from 39.8% to 21.7%) and “leg propulsion action” (CV% from 40.8% to 21.7%) the NL group increased the homogeneity, which is an indicator of an effective learning. LI group increased the non-homogeneity in all the items except in “water entry” (CV% from 14.3% to 9%) and in “buoyancy” (CV% from 34.5% to 20.6%).

Table 7. Results of Pre and Post Langerdofer-Bruya aquatic motor competence tests, expressed as mean $\pm$ standard deviation. Statistical differences ($p < 0.05$) of intra-group analysis are reported in Pre vs Post columns. Statistical differences ($p < 0.05$) of inter-group analysis are reported “LI vs NL pre” and “LI vs NL Δ ” columns. ES= effect size. * = $p < 0.05$.

	Linear			Non-Linear			Linear		Non-Linear					
	Pre (A.U)	Post (A.U.)	Δ (A.U.)	Pre (A.U)	Post (A.U.)	Δ (A.U.)	Pre vs Post	ES (r2)	Pre vs Post	ES (r2)	LI vs NL Pre	ES (φ)	LI vs NL Δ	ES (φ)
Water entry	2.8 $\pm$ 0.4	2.9 $\pm$ 0.3	0.1 $\pm$ 0.4	3.0 $\pm$ 0.2	3.0 $\pm$ 0.1	0.0 $\pm$ 0.3	0.059	0.040	0.143	0.004	0.023*	0.058	0.143	0.024
Breathe control and immersion	2.8 $\pm$ 0.4	3.2 $\pm$ 0.5	0.5 $\pm$ 0.7	2.5 $\pm$ 0.5	2.9 $\pm$ 0.4	0.2 $\pm$ 0.5	0.001*	0.131	0.138	0.080	0.166	0.022	0.138	0.025
Buoyancy	1.6 $\pm$ 0.5	4.0 $\pm$ 0.8	2.5 $\pm$ 1.0	1.7 $\pm$ 0.7	3.4 $\pm$ 0.7	1.7 $\pm$ 0.9	0.000*	0.357	0.001*	0.380	0.674	0.002	0.001*	0.129
Arm propulsion action	1.0 $\pm$ 0.0	2.3 $\pm$ 0.4	1.3 $\pm$ 0.4	1.0 $\pm$ 0.0	2.0 $\pm$ 0.0	1.0 $\pm$ 0.0	0.000*	0.388	0.000*	0.539	1.000	0.000	0.000*	0.163
Arm recovery action	1.0 $\pm$ 0.0	2.3 $\pm$ 0.5	1.3 $\pm$ 0.5	1.0 $\pm$ 0.0	2.5 $\pm$ 0.5	1.5 $\pm$ 0.5	0.000*	0.385	0.048*	0.435	1.000	0.000	0.048*	0.044
Leg action	1.0 $\pm$ 0.0	3.2 $\pm$ 0.5	2.2 $\pm$ 0.5	1.1 $\pm$ 0.4	3.1 $\pm$ 0.7	2.0 $\pm$ 0.7	0.000*	0.381	0.146	0.422	0.355	0.010	0.146	0.024
Combined movement	1.0 $\pm$ 0.0	2.5 $\pm$ 0.6	1.5 $\pm$ 0.6	1.0 $\pm$ 0.0	2.4 $\pm$ 0.5	1.4 $\pm$ 0.5	0.000*	0.369	0.298	0.439	1.000	0.000	0.248	0.012
Total	11.2 $\pm$ 1.4	20.5 $\pm$ 3.7	9.4 $\pm$ 2.6	11.3 $\pm$ 1.1	19.1 $\pm$ 1.3	7.8 $\pm$ 1.4	0.000*	0.352	0.008*	0.414	0.725	0.001	0.008*	0.08

4.1.4.1.3. Global results emerged at the end of the swimming course in LI e NL pedagogy group related to the expectations of the parents and the perception of the children

Results emerged from GT are shown in Table 8. Data are presented as percent.

Table 8. The Table is divided into three thematic areas. On parents' perception side, the first line refers to the physical literacy's sphere, the second line is related to the child dimension and the last one regards with the aspects of the instructor. On children's perception side, the first line refers to the relationship with the pool environment, the second one is related to the water competence and the last one regards with the psychosocial aspects.

EDUCATION							
Parents' participation				Children's participation			
		LI	LI			LI	NL
Physical literacy (PHY)	1.1 Do you think that the swimming school has been beneficial for the health, the physical development and the wellness of your son/daughter? A. Yes, completely B. Yes, partially C. Not at all D. No, I don't.	67%	80%	Relationship with pool environment (PHY)	1. At the swimming pool, how do you put your swimming costume, hat and bathing shoes on? A. I do it myself B. Sometimes I do it myself C. My teacher al-ways helps me	60%	80%
	1.2 Do you think that the swimming course has enabled your son /daughter to learn the swimming technique? A. Yes, completely B. Yes, partially C. Not at all D. No, I don't.	71%	29%		2. How do you feel when you go to the swimming-pool? A. I love going to the pool B. It's hard to go to the pool C. They make me go to the pool	70%	93%
	1.3 Do the lessons proposed allowed your son/daughter to have a greater confidence with water and swimming pool environment? A. Yes, completely B. Yes, partially C. Not at all D. No, they don't.	95%	80%				
Child (CHI)	2.1 How does your son /daughter relate in the swimming pool environment?	88%	50%	Water competence (CHI)	3. How do you get into the water? A. I jump in right away B. I get into the water gradually C. I don't want to get into the water	94%	100%

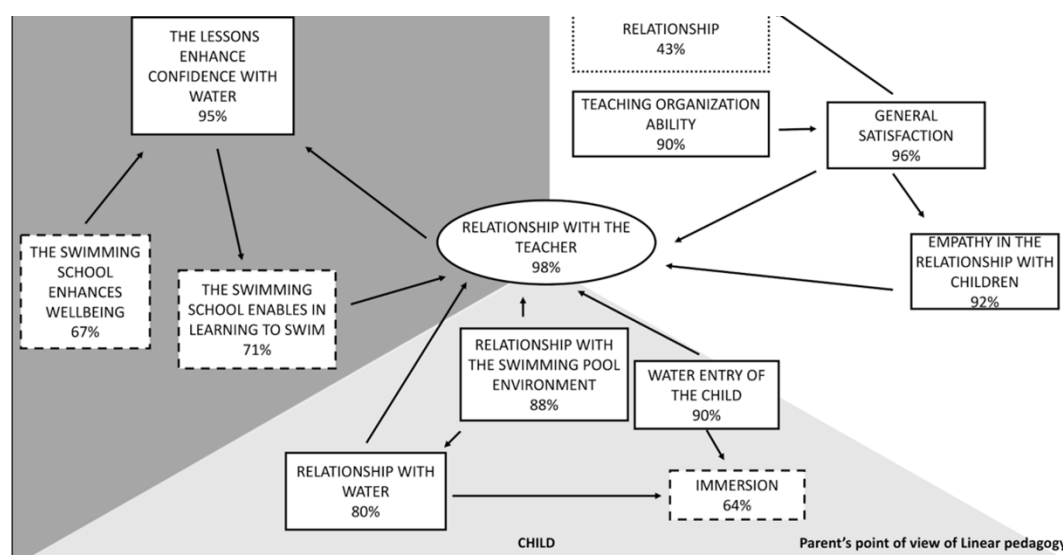
	A. He/she is confident B. He/she feels at ease C. He/she needs support D. He/she doesn't want to go to the swimming pool				
	2.2 How does your son/daughter get into the water? A. He/she jumps in right away B. He/she get into the water gradually C. He/she needs support D. He/she doesn't want to get into the water	90%	95%	4.Can you go up the ladder? A. I can get up it in the deep end B. I can only get up it in the shallow end C. I can't get up the ladder	94% 100%
	2.3 How does he/she live the immersion? A. He/she enjoys it a lot B. He/she feels at ease during the immersion C. He/she doesn't like it D. He/she is scared about it	64%	90%	5.Can you float? A. I can float on my own B. I can float with the help of floats C. I can't float	87% 86%
	2.4 Does your child feel at ease when he/she is in water? A. Always B. Usually C. Sometimes D. Never	80%	92%	6.Can you stay in the deep end without needing any equip-ment to help you? A. Yes, I can do that B. Only sometimes C. No, I can't do that 7.Can you put corks in the box? A. Yes, a lot and in the deep end B. Yes, but only in the shallow end C. I can't put any in	60% 93% 93% 94%
Teacher (TEA)	3.1 How is the relationship between your child and the teacher? A. Very positive B. Positive C. Negative D. Very Negative	98%	90%	8.How many corks do you think you are able to put on the rope? A. A lot in the deep end B. A lot in the shallow end C. None	47% 27%
	3.2 Can you be satisfied about the swimming school offered by the teacher? A. Yes, completely B. Yes, partially C. Not at all D. No, I can't.	96%	50%	9. When you have a race with your friends in the deep end, what place do you usually come in? A. One of the first B. In the middle C. One of the last	87% 100%
	3.3 Has the teacher been able to create an empathic relationship with the chil-dren?	92%	86%	10. Do your friends choose you to play in the water?	

A. Yes, completely B. Yes, partially C. Not at all D. No, he hasn't.			A. They always ask me to play B. Sometimes they ask me to play C. They never let me play	
3.4 Do you think that the teaching organization has been effective?	90%	85%		
A. Always B. Usually C. Sometimes D. Never				
3.5 Do you think that the teacher has promoted the relationship between peers?	43%	21%		
A. Yes, completely B. Yes, partially C. Not at all D. No, he doesn't.				

4.1.4.1.4. Specific results related to the parents' perception questionnaire post intervention, qualitative analysis

The results of the parents' questionnaires are showed below. Figure 3 presents the diagram according to Grounded Theory that illustrates the results of the questionnaire which the parents of LI group children were subjected to.

Figure 3. Diagram related to the parents' perception of LI group as revealed by the administered questionnaire



Relationship with the teacher represents the **Core Category (98%)**. **General satisfaction (96%)** seems strongly dependent on it and it is supported by a good teaching organization.

The empathy created by the teacher with the children allows the development of the relationship with teacher.

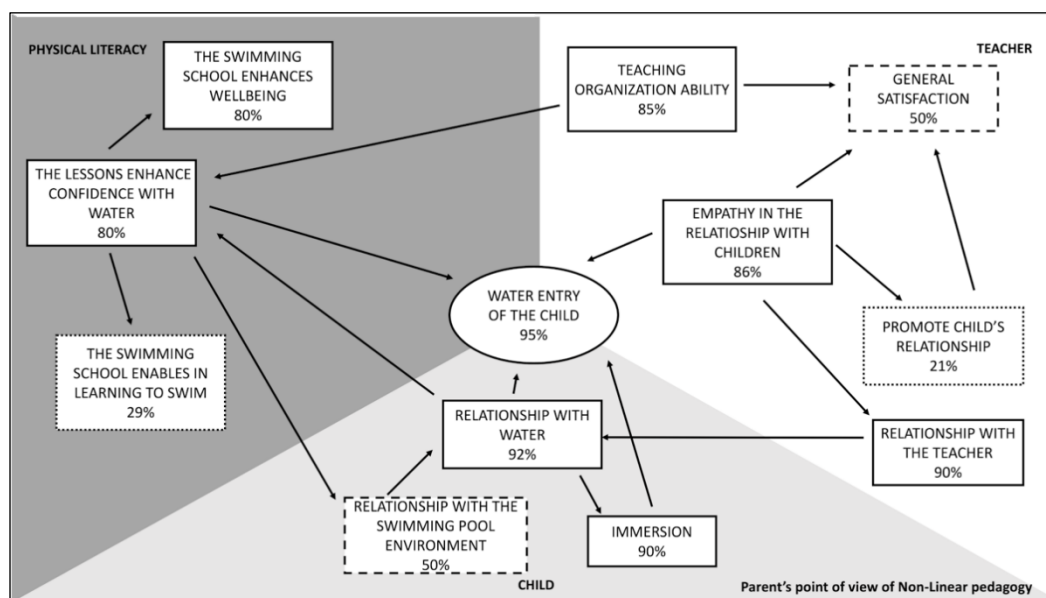
The influence of the teacher on the social sphere that includes children and his or her relationship with the peers, is not perceived as fundamental.

The water competences in the child sphere are all related to the Core Category. In fact, in parents' opinion, a good relationship with the teacher let a confident entry into the water of the child, developing a good relationship with the

swimming-pool environment and a good relationship with the water. The **immersion** is a positive experience only for the **64%** of the children.

Learning to swim is a more crucial aspect for the parents of the LI group. Positive answers to the question “Do you think that the swimming course has enabled your son /daughter to learn the swimming technique?” account for **71%**. From the parents’ point of view, **wellbeing** created by the swimming school is crucial for the confidence with water of the children (**67%**).

Figure 4. Diagram related to the perception of NL parents’ group according to the results of the questionnaire administered



As shown in the Figure 4, the main theme, emerged from the questionnaire vaulted to investigate parents’ NL perception, is related to the **water entry of the child (95%)**, which represents the **Core Category**. Water entry requires to have confidence with the water, which is an essential aspect of swim learning. On the other hand, in figure 4, **learning to swim** does not result to be a relevant aspect in the physical literacy sphere (**29%**), but rather the **wellbeing (80%)** of the child. As previously mentioned, getting into the water presupposes that the child is confident and has a good relationship with the water. The positive answers to the question “Does your child feel at ease when he/she/is in water?” in fact are related to the balance, to move into the fluid with the proper pushes and to the mastery of

breathing (Stallman, 2017). These are crucial aspects required in order to learn the **immersion**, which represents another obvious theme for the parents of NL group with the **90%** of positive answers.

According to the parents' point of view, having empathy with the children is important for the teacher in order to facilitate the water entry of the child. On the other hand, would not seem as crucial the ability of the teacher to promote the relationship between the peers.

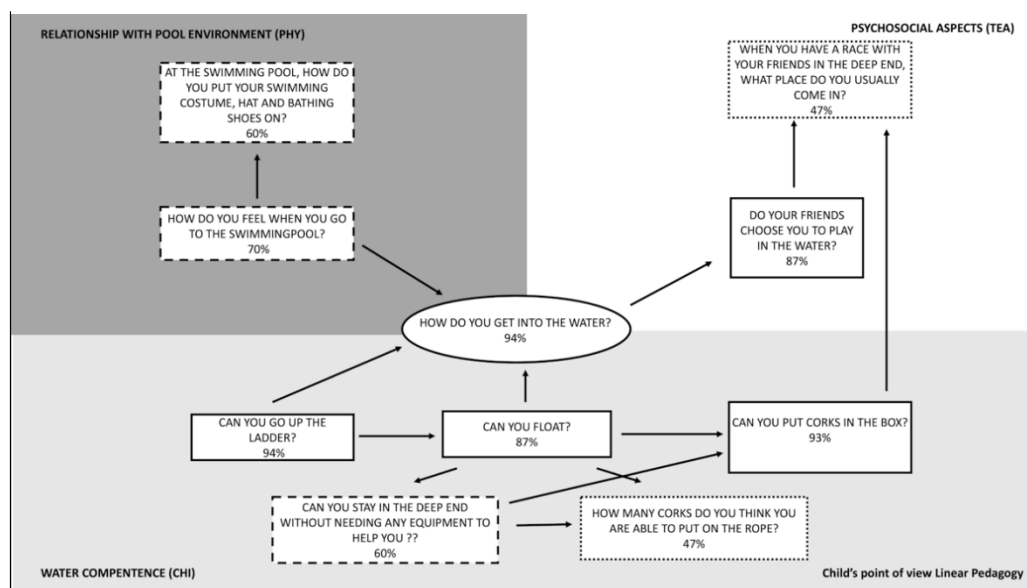
Teaching organization allows to develop water confidence on the side of the child and indirectly influences the predisposition to entering the water.

General satisfaction of the child for parents of children in NL seems to be low (**50%**).

Establishing a good relationship with the swimming pool environment is perceived as a non-strictly need in order to promote the relationship with the water and water confidence in aquatic environment.

4.1.4.1.5. Specific results related to the perception of the aquatic competence of the children post intervention, qualitative analysis

Figure 5. Diagram related to the perception of the children of the LI group according to the results of the pictorial scale indicating the percentage of positive responses.



In figure 5 the diagram, according to GT methodology, about the analysis emerged from the pictorial scale which were subjected the children is shown.

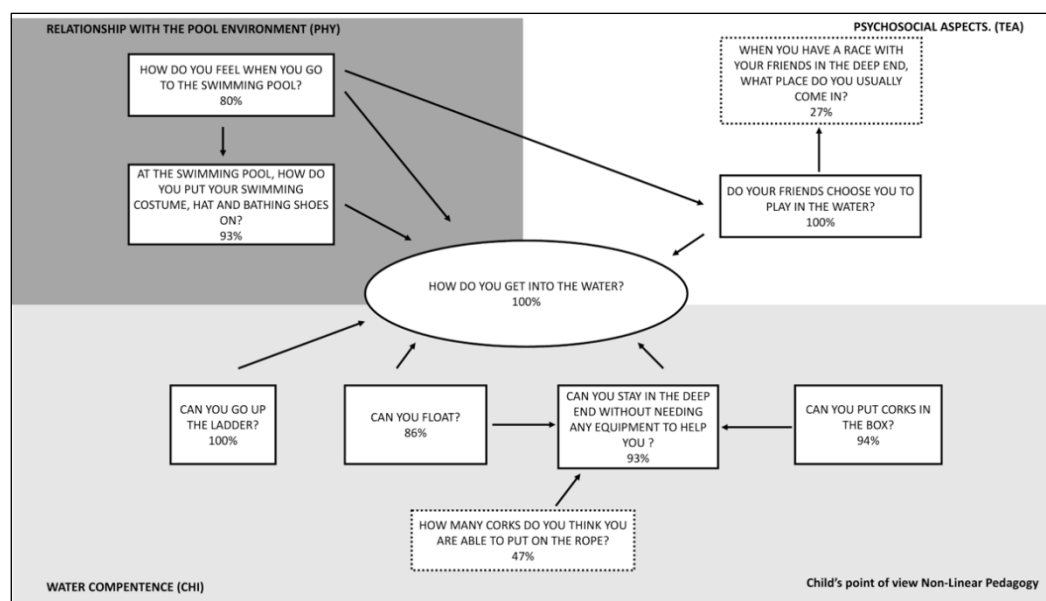
Most of the children of the LI group **get into the water happily (94%)** jumping into it or entering gradually into it. Getting into the water with confidence presupposes to have a quite good relationship with it and to be able to go up the ladder in order to exit both in high or shallow water and to float alone or with the help of corks. A good buoyancy allows the children to move easily into the fluid and to reach in putting corks in a box quite easily both in high and in low water.

The perception of a good buoyancy let the child to verify if he or she is able to stay in water without the help of corks, even if it turns out to be more difficult to put corks on the rope. Although there is a good buoyancy and displacement in water, this unsureness could be motivated by an alteration of the spatial perception and to the difficulty in controlling the fine coordination in the aquatic environment,

as well as to the pushing action of the legs in order to maintain buoyancy (Howells & Jarman, 2016; Stallman, 2017)

Getting into the water with confidence let the children to feel at ease in aquatic environment and to promote a **positive relationship with the swimming pool environment (70%)**. The pool environment predisposes them to obtain a greater **autonomy on practical aspects** aimed to the personal training such as putting on the swimming costume, the hat, and bathing shoes. This aspect is not completely achieved by all the children yet **(60%)**. A comfortable environment let a better development of their own autonomy and self-efficacy (Diem, 1982). Getting into the water with sureness give an image and a higher self-perception to the other children that predisposes them **to be chosen by their peers** to play into the water **(87%)**. In fact, not all the children are chosen for play into the water by the others.

Figure 6. Diagram related to the perception of the children of the NL group according to the results of the pictorial scale indicating the percentage of positive responses.



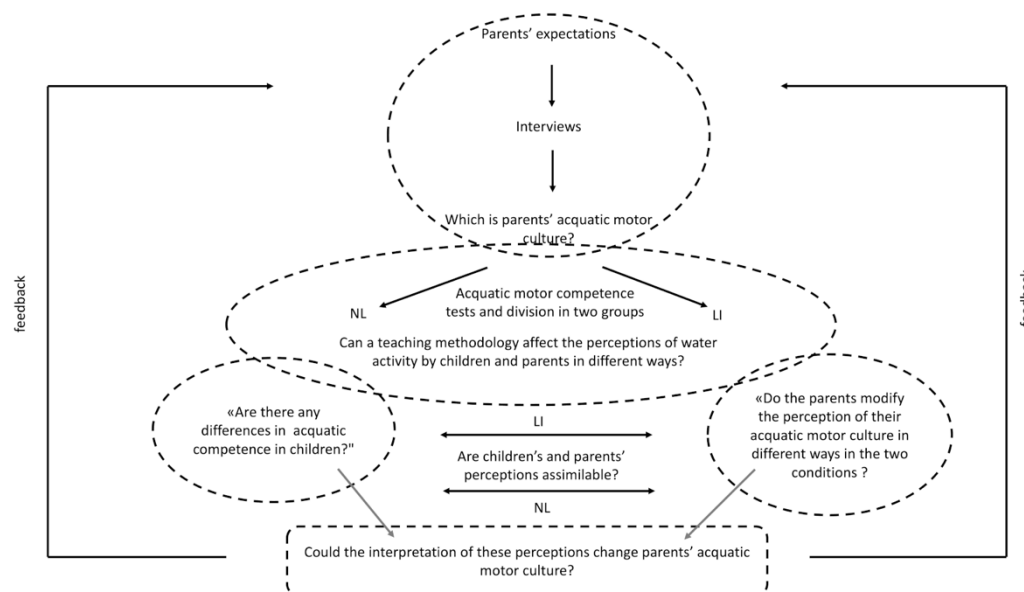
All the children (figure 6) of NL group **get into the water with ease (100%)** by jumping into it or entering into it gradually, and all of them managed to exit using the ladder both in high and shallow water. Most of them succeed in floating with and without the help of corks and this allows them to stay in water without invalidating difficulties and to put corks in the box both in high water and in low water. Putting corks on the rope is a quite difficult exercise for the NL group too. From a relationship point of view, the teacher's ability to create situations encourages the learning and allows the children to develop a sufficient self-esteem in order to promote the relationships within the group. This aspect allows all the children **to be chosen by the peers to play in the aquatic environment (100%)**. The preparation of the activity by the teacher, according to a non-linear learning approach, let the children develop a greater autonomy, also in the training of the activity as putting the swimming costume, the hat and the bathing shoes by themselves. We can assume that they show **autonomy on practical aspects (93%)**. In fact, all of them are able to use the changing rooms independently. The self-efficacy sense allows them to feel at ease in the **swimming pool environment (80%)**.

4.1.5. Discussion

4.1.5.1. *Parents' preliminary interview and GT related to parents' perception*

Analysis of the preliminary interview (Figure 7) showed that parents believe aquatic activity has a positive effect on the physical development of the child and that this is also related to the acquisition of a good swimming competence and the learning of the technique. The analysis of the interviews also illustrated the importance of improving social and educative aspects. However, the re-processing of the questionnaire's data at the end of the activity, and after the division into the two groups, reveals two different scenarios.

Figure 7. Graphical representation about the fields of investigation of in the research work



Comparing parents' questionnaires of LI and NL groups, 8 out of 12 items presents better results in the LI group. Get into the water of the child represent the positive core category (95%) of NL group, while "relationship with the teacher" is the main positive aspect in LI group (98%). From this comparison we can learn that the parent of NL group perceives the child at the center of the method, while in the LI

group the teacher has a crucial role. As a result of this comparison, a different perception of the swimming school emerges.

In NL approach great emphasis has given to the creation of a suitable environment in order to allow the development of the competence autonomously, through a three-valued approach as described in the Self Determination Theory (SDT) (Deci & Ryan, 2013). In SDT the aspects related to autonomy, competence and social context take shape in the Cognitive Evaluation Theory (CET) mini-theory, in which the intrinsic motivation arises from the satisfaction in achieving results with their own abilities. In CET the perception of competence and the autonomy have a critical role in order to maintain intrinsic motivation, crucial in sport for children's participation in healthy behaviors across the life span (Deci & Ryan, 2013; Lopes et al., 2021).

NL group better perceived a positive relationship with water (92%) and immersion (90%) differently from LI group (80% and 64% respectively). The distinction in the perception of these two aspects can be due to the free exploration of the child who discover the environment respecting her/his own learning time, without forcing or anticipating the timing. Immersion is not lived as a constriction, so this method allows the children to learn this fundamental in a less aggressive way (Pansu, 1998). However, the percentage of positive responses to the question "Do the lessons proposed allowed your son/daughter to have a greater confidence with water and swimming pool environment?" resulted to be higher in LI group (95%) than in the NL group (80%). The percentage of positive responses to the question "Do you think that the swimming course has enabled your son /daughter to learn the swimming technique", is higher in the LI group (71%) than in the NL group (29%). The LI approach was oriented towards the motor learning, in which the acquisition of swimming technique resulted to be crucial through a systematic and gradual didactic progression. The role of the teacher in LI method was crucial because resulted to be a mediator of a technical learning in a more incisive and determinant way, through the organization of more dynamic and progressive lessons (90% Vs 85%). The level of general satisfaction investigated with the question "Can you be satisfied about the swimming school offered by the instructor?", resulted to be lower in NL parents' group than the LI group (50% and 96% respectively): the feedback regarding the immediate learning of swimming technique was related to the aquatic culture of the parents that in the preliminary interview confirmed to be

source of satisfaction. These results presuppose the parents' awareness regarding time and methodology necessary to acquire the fundamental motor skill to reach a proficiency barrier, useful for health and aquatic well-being (Brian et al., 2020). Counter wise, this competence needs acquisition of specific knowledges that are not owned by the parents (Quan et al., 2015). The impression that the parents had of LI group was that the lesson was organized in a more dynamic and challenging way, and that contributed to a better physical development because turned out to be clearer and more understandable by the observer. This methodology enforced the parent's idea expressed in the preliminary interview and of the water activity. In LI methodology, social aspects were developed in a different situation than in the NL group because the different organization of the water activity which was obtained with a teaching styles based on reciprocal observations (Nielsen et al., 2014). In order to meet the priority of the parents, the child had to obtain good aquatic competences to ensure a safe future that prevents the risk of drowning (Asher et al., 1995; Morrongiello et al., 2013) In the literature is evident the relation between the parent's involvement and the child's behavior (Serna & Martínez, 2019). It is known that, some variables such as parental relationship may influence the well-being of the child (Guevara et al., 2021). In particular, aquatic experience of the child based on teacher centered pedagogy (LI), positively evaluated by the parents, could (Garcia et al., 2019) slow down the natural and optimal learning process. This became particularly relevant when the teaching method presented excessive pressure to the learner (Rudd et al., 2020).

4.1.5.2. *Actual motor competence and perceived motor competence of the children*

The children of LI group achieved a greater aquatic competence level than the NL group, according to the parents' expectations. According to literature, the method of how someone learns to swim is significant (Irwin et al., 2019). As shown in table 7, the children of the LI group were better about 7.3% in total results than children of the NL group. NL group instead achieved a greater homogeneity at the end of the swimming school than the LI group. We can assert that non-linear pedagogy, based on student centered pedagogy, contributed to reducing the intra-groups competence gap. Data seems to agree to the aims of physical literacy: in the early

to middle childhood period is particularly important to consider the individual learning path (Rudd et al., 2020).

Regarding the perceived motor competence of the children, 7 out of 10 items presents better results in NL group. Children of LI and NL group are both able to achieve tasks as putting the swimming costume, the hat and the bathing shoes on. The NL group perceived a greater positive mood (93% NL vs 70% LI) and show off a greater autonomy in the changing rooms ("At the swimming pool, how do you put your swimming costume, hat and bathing shoes on?" 60% LI and 80% NL). The guided discovery and the free exploration of non-linear pedagogy let the child develop a greater self-efficacy because the child is allowed to reach the steps of the learning path with his/her own time (Rudd et al., 2020). This freedom allows him/her to acquire more confidence in his/her own competences developing a greater autonomy even in the tasks out of the swimming pool. The literature reported that, the greater is the perception of aquatic competence experienced by the participants, the greater is their real aquatic competence. The teacher would be responsible to reinforce a positive self-concept in children from three to six years old, to promote the development of perceived aquatic motor competence and help them to overcome fears which could compromise the development of certain actions (Moreno Murcia et al., 2017; Moreno-Murcia et al., 2020). The 47% of the children in LI group and the 27% of the children in NL group claim to be among the first places during races. We can assume that a student-centered pedagogy approach, as in NL group, didn't emphasis the competition in the activity proposed while the opposite occurred in teacher-centered pedagogy, as in LI group ("When you have a race with your friends in the deep end, what place do you usually come in?" 47% LI and 27% NL).

This may depend on the emphasis given by the teacher (more oriented in a theory based on performance and less on the task), on the comparison with the peers, and on how much the teacher stimulated the aspects related to the competition. Furthermore, learning become difficult when the activity is compulsory and does not always respect the learning time of the individual (Ames, 1984; Nicholls, 1989). Both the children of LI group (87%) and the children of NL group (100%) affirm to be frequently chosen by the peers during games ("Do your friends choose you to play in the water?"). Relationship with the peers resulted to be well structured both in LI and in NL group since the dynamics, given by a greater autonomy derived

from a greater self-esteem, were directly managed by the peers, with a limited intervention of the teacher. In LI group, the direct approach of the teacher may have influenced some dynamics (Rudd et al., 2020).

Respecting the timing of achieving the aquatic competences related to stay in water without the help of corks in NL group (93%) allowed the child to perceive better his/her self-efficacy than in the LI group (60%). Developing a perceived motor competence, based on own actual capacity, allows a wellbeing status indispensable to build a physical literacy that includes affective, physical, cognitive and behavioral spheres (Whitehead, 2013).

4.1.5.3. *Practical applications*

The aquatic motor culture of the parents can be modified through increasing their awareness about the differences and gaps between their perception and the children's perception. Moreover, the evaluation of the homogeneity of the group could be a useful tool in order to verify the effectiveness of the learning. In particular, the increasing of homogeneity in the NL group, as evidenced by the results related to the actual motor competence tests, can be recognized as an index of effectiveness of the learning. In the LI group, the decreasing of homogeneity in the results of the same tests, let the children improve their aquatic technique evidencing the gap between the ones which are more able than others. This gap demotivates the most vulnerable children. This educational view of the swimming school could be motivated during the preliminary meeting with the parents.

We were able to see that the consideration that parents often have initially regarding the motor activity is strictly linked to the performance and the achievement of results; it is difficult for them considering the psycho-physical and social well-being of their children. Putting parents in front of the point of view of the children could enable them to modify their knowledge related to the aquatic motor culture, also taking into account the relational, emotional and psychological aspects thus helping to grow independent and self-confident children, in themselves and in their abilities. For this reason, the swimming school should have a more formative and educational vision, with the aim to lead the parent towards the awareness that the children and their needs must be placed at the center of

learning in order to let them live a positive experience with positive effects on its physical literacy and health status across the life span (Lopes et al., 2021).

4.1.6. Conclusions

In conclusion, both children and parents' group presented substantial differences related to the perception of the activity proposed.

We can affirm that NL approach was more appreciated by the children than the LI approach, while for the parents' group, LI method resulted to be more rewarding than the other because the initial expectation were satisfied. Preliminary interview let us verify the children behaviors expected by the parents at the end of the course. It was a useful tool to expand the parents' knowledge related to their aquatic motor culture, highlighting the aspects related to autonomy, self-efficacy, achieved self-esteem and achievement of a healthy status in anatomical, physiological, psychological and sociological terms that can be conveyed by the swimming activity. We retained interesting to note that children obtained more evident progress in learning the swimming technique through the LI method, but there was a gap in what they perceived and what they achieved through the motor tests (Rudisill et al., 1993). On the other hand, the children who learnt with the NL method, developed an higher sense of awareness, self-efficacy (in changing rooms and in the relationship with the water) and self-esteem (in the relationship with the peers), which implies a greater assertion of soft skills (Brian et al., 2020). The gap between the perceived competence and the actual competence depends on the lack of consciousness of their own abilities. This rare awareness is crucial in children which are between 4 and 8 years old and it is due to the inability to abstract the thoughts. With the growth and the development of the logical thinking, the child will be able to reduce the gap between perceived and actual motor competence (Estevan & Barnett, 2018).

This reflection is crucial for the didactic planning of the motor development of the child. It would be appropriate to emphasize how the educational view, differently from the utilitarian and sportive approach, could stimulate, referring to the physical literacy culture which include the individual need (Chow et al., 2011), the

solidarity and attention to the most vulnerable children, improving their self-esteem through a better perception of motor competence.

4.2. EFFECTS OF VARIED PRACTICE APPROACH IN PHYSICAL EDUCATION TEACHING ON INHIBITORY CONTROL AND REACTION TIME IN PREADOLESCENTS

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4.2.1. Abstract

This study aimed to investigate the effects of nonlinear and linear varied practice compared to a constant linear practice on inhibitory control and reaction time, which are capacities that involve cognition in preadolescents. Eighty-three participants in the 8th grade participated in the study. They were assigned to two experimental groups (varied practice), taught using non-linear pedagogy (NLP) and linear pedagogy (VLP), respectively, or one control group (constant practice), taught using linear pedagogy (CLP). All participants were tested for inhibitory control (congruent and incongruent conditions) and simple reaction time. Overall, varied practice (both linear and nonlinear) induced larger improvements than constant practice under both congruent ($p = 0.026$) and incongruent ($p = 0.013$) conditions of inhibitory control. Additionally, VLP provided greater improvements in inhibitory control (for the incongruent condition) than NLP and CLP. Although NLP and VLP may be preferable to CLP approaches for enhancing executive functions in preadolescents, VLP seems to be the most effective approach aimed to improve cognition within PE classes.

Keywords: school; linear didactics; nonlinear didactics; teaching styles; executive functions

4.2.2. Introduction

The World Health Organization recommends a specific daily dose of physical activity, from moderate to vigorous intensity, related to age and gender for health benefits (World Health Organization, 2020). Moreover, aerobic exercise is also considered as a “useful drug” to reduce age-related cognitive decline (Prakash et al., 2015), as well as a preventative measure for cardiovascular and metabolic diseases (Hayes et al., 2014).

In preadolescents, aerobic exercise affects both prefrontal executive control and hippocampal function (Buck et al., 2008) and has major effects on executive functions (Davis et al., 2011) involved in attention and concentration (Diamond,

2013). The prefrontal cortex, which is associated with executive functions, continues to undergo substantial changes during adolescence, as does the myelination of axons. This caused an increase in white matter and a decrease in grey matter, which led to a synaptic reorganization in 13–14 years old children (Theodoraki et al., 2020).

As scientific literature has confirmed, the development of executive functions is also related to varied physical activity and to an adequate dose of exercise (Donnelly et al., 2016; Vazou et al., 2019). In this way, the literature has evidenced the necessity to consider both quantitative aspects (related to health) and qualitative aspects (related to motor control) of movement, as the same brain areas (e.g., prefrontal cortex) used to control the cognitive processes are activated during physical activity (Pesce, 2012; Tomporowski et al., 2015). Although the brain reaches 95% of its development by the age of 6 (Spear, 2000), the prefrontal cortex takes about 20 years to achieve its ultimate growth (Lenroot & Giedd, 2006). As a consequence, inhibitory control can be particularly critical for preadolescents. This is due to the immature limbic system and prefrontal cortex and to a predominance of glutamatergic neurotransmission compared to gamma-aminobutyric acid neurotransmission, which remains under construction. This lack of inhibitory control might be responsible for immature and impulsive behavior and neurobehavioral excitement (Arain et al., 2013). With an immature capacity to exert adequate cognitive control, preadolescents have difficulty managing executive functions, especially inhibition, which is connected to perceptual-motor executive skills (Smith et al., 2018; Somerville et al., 2011).

In a specific motor context, executive functions, such as inhibitory control, are required with a simple reaction time, which is the capacity to respond quickly to a stimulus. It embodies the relationship between perception and motor action (Mann et al., 2007). According to Vickers (Vickers et al., 2011), the average reaction time considerably decreases with practice in rapid hand reaction movements, due to a greater efficiency of nervous system information processing. Therefore, the higher the attention to the task and the inhibitory control, the quicker the response (Ghodrati et al., 2021; Logan et al., 1984; Posner, 1978).

Reaction time depends on cognition and presents sensitive periods within preadolescence (from 7 to 12–13 years old) (Horníková et al., 2019). An immature stage of the brain with excess synapses, possibly due to a burst of proliferation,

may decrease the performance and the frontal activation (Blakemore & Choudhury, 2006). Two research lines can explain the pedagogies related to creating a transfer between motor activity and cognition. The first line refers to physical activity and cognitive commitment (Pesce et al., 2009). Integrating motor activity and cognitive tasks could improve cognitive development through interdisciplinary learning. Therefore, the child learns through motor activity, which is the means. Furthermore, voluntary control of the cognitive and motor behaviors based on transfer and interaction between the motor activity practiced in the gym and other intellectual activities could also improve, as executive functions played a key role. The second line is related to embodied cognition, which is founded on sensory-motor interaction with the environment, as brain development occurs due to the execution of the action and not to the cognition itself. This way, motor activity is the end; promoting the action, cognition develops (Engel et al., 2013).

Two different methodologies have been based on these two research lines in a pedagogical context. Linear and nonlinear pedagogy approaches are means for didactics which can facilitate the transfer between motor activity and cognition. In particular, repetition and variation represent the two variables of linear and nonlinear pedagogies, which favor the development of cognitive processes. The linear pedagogy is based on the cognitive (“central”) theory (Renshaw et al., 2010; Rudd et al., 2020), and it is based on deliberate practice, founded on understanding and imitation of executive models. It traditionally supports learning by constant practice based on structuring, understanding, and repeating skills until they are acquired, focusing on a specific model of movement (education to the movement). The nonlinear approach is based on the ecological-dynamic theory (peripheral). It stimulates the learner to find more personal solutions due to the continuous exploration of different and creative motor behaviors and the flexible usage of attention to solve environmental problems (Liao & Masters, 2001; Masters, 2000). The nonlinear approach allows better creative thinking outcomes than the linear approach (Pesce et al., 2017; Richard et al., 2018; Santos et al., 2016). However, at the beginning of an educational process, linear pedagogy allows the learners to learn and structure the motor skills (giving models to understand, reproduce, and memorize), favoring the initial acquisition of the automatisms through repetition. It also allows more quick, economical, and non-dispersive use of attentive

resources and cognitive efforts than does nonlinear learning (Tanaka et al., 2011). Furthermore, the educator's motivation in the linear pedagogy is essential and facilitates the acquisition of new skills and the use of selective attention (Hein et al., 2012).

Nevertheless, while linear and nonlinear approaches supposedly contrast each other, they are also comparable. To some extent, they are similar when the linear pedagogy approach is based on variation. In linear pedagogy, variations can relate to the coordinative difficulties defined by the characteristics of the task and the executive contrasts, which allow for the exploration of all the specific feelings of the body and movement, through a kinesthetic differentiation, to learn a model of motor skill (Davids, 2010; Guadagnoli & Lee, 2004). In nonlinear pedagogy, variations can relate to the functional difficulties occurring. The choice about a challenging task depends on the individual's skill level, on his/her perception of the situation, and on his/her personal strategies aimed to solve environmental problems. The discovery is indirectly guided by the teacher (Guadagnoli & Lee, 2004).

Contextual interference is another common aspect of the two approaches. It is a robust learning phenomenon that is the interaction between many combined motor abilities and situations based on varied or randomized practices that create motor disturbance situations through new, unknown, or different stimuli. These stimuli force the focus of attention on the main task to better perceive the sensations derived from it and obey a constant adaptation and alert. Therefore, they induce a decrease in the sensibility threshold and an increase in adaptation capacity, which leads to better use of the body in general and specifically, to the range of movement referred to in the model (Calvo & Gomila, 2008). Interference and practice variation stimulate a continuous redefinition of motor programs and a kinesthetic perception of actions (Hall & Magill, 1995; Henz et al., 2018; Wulf & Lee, 1993).

Nonetheless, other hallmarks, such as the learners' active involvement by reflection (obtained through reciprocal observations and self-check, during varied linear applications) and guided discovery (as in the application of nonlinear styles) can be retrieved in both pedagogical approaches as further action to advance cognitive functions (Mosston & Ashworth, 2008; Renshaw et al., 2010; Rudd et al., 2020).

Motor abilities can be acquired by focusing on the movement form (external appearance of actions) or content (inner motor processes stimulated through

reflection based on questions, variation, and contextual interference). Reflective practices could be focused on the different modalities in which a motor task can be solved (nonlinear approach) or on the perception of kinesthetic sensations compared to executive results (varied linear approach) (Myer et al., 2013).

In a linear pedagogy approach, the attention is characterized by a monotasking experience focused on the main goal of learning. In a nonlinear approach, the research on perceptive learning showed that an embedded learning frequently changes operational conditions and induces the learner to continuous adaptation of the attention by multi-tasking experiences, promoting a “learning to learn”(Thrun & Pratt., 1998)

Even if the scientific literature showed that physical exercise in a dynamic and changing environmental context could improve attention skills and cognition more than in a static and predictable context (Formenti et al., 2019), to the best of our knowledge, no study investigated the effects of a different varied and constant practice on executive functions and clinical reaction time.

The present study investigated the effects on inhibitory control and reaction time of a varied practice characterized by two different educational approaches (nonlinear and linear pedagogy) compared to a constant practice characterized by the prescriptive linear pedagogy approach. We hypothesized that variations would lead to inhibitory control and reaction time effects superior to those obtained through constant practice. Further-more, variations in a linear approach should produce comparable cognitive benefits to a nonlinear approach. Linear approach variations are aimed at fostering better kinesthetic perception and movement-specific awareness, while nonlinear approach usually applies random practice under the dynamic system’s ecological theory, which is aimed to favor an embodied cognition and a better general body awareness.

We can synthesize our research questions as follows: does a reflective approach based on movement content lead to different cognitive transfer effects than an approach based on the movement form? Does a varied linear approach based on a reflective practice determine the same cognitive transfer effects as a nonlinear approach?

4.2.3. Materials and Methods

Eighty-three students from two Italian secondary schools (8th grade) participated in the study (age 13.2 ± 0.3 years, height 1.60 ± 0.08 m, weight 48.4 ± 8.6 kg, body mass index 18.7 ± 2.2 m/kg²). The number of participants satisfies the sample size previously calculated by the G*power software ($n = 66$). Due to practical reasons (intervention study performed during the curricular PE lessons), a quasi-experimental design was applied to establish cause-and-effect relationships between independent (teaching approach) and dependent (inhibitory control and reaction time) variables. Two public schools belonging to the same local area were involved in the study to prevent threats to research reliability, perhaps originating from differences in the participants' socioeconomic and cultural features. A control group was established among classes of one of the schools whose teachers previously declared to teach their students by a constant linear pedagogy (CLP) approach (one class designated). The experimental groups were designated in the other school to prevent the CLP teacher from any direct or indirect influence on his teaching approach by possibly watching the PE lessons led according to the experimental procedure. Therefore, two school classes acted as experimental groups and were taught with varied nonlinear pedagogy (NLP) and varied linear pedagogy (VLP), respectively, by two PE teachers with expertise in nonlinear and linear approaches collaborating with our research team (Table 10).

Table 10. Participant demographics.

	NLP (N = 27; 9 f, 18 m)	VLP (N = 28; 10 f, 18 m)	CLP (N = 28; 11 f, 17 m)
Age (yrs)	13.0 $\pm$ 0.0	13.0 $\pm$ 0.2	13.0 $\pm$ 0.2
Body mass (kg)	50.5 $\pm$ 8.6	49.4 $\pm$ 9.2	45.4 $\pm$ 7.3
Stature (cm)	161.3 $\pm$ 7.6	160.3 $\pm$ 10.0	159.9 $\pm$ 7.1
BMI (kg/m ²)	19.3 $\pm$ 2.4	19.1 $\pm$ 2.2	17.7 $\pm$ 1.8

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy; f: females; m: males; BMI: body mass index.

After being well informed about the study's potential risks and benefits, the participants and their parents or guardians provided written consent. They were allowed to withdraw from the study at any moment. The study was carried out under the Helsinki Declaration of 1975 and was approved by the Ethics Committee of the Università degli Studi di Milano.

4.2.3.1. Procedure

Before starting the training period, the participants were familiarized with the testing procedures, and inhibitory control and simple reaction time were assessed. In the sub-sequent 12 weeks, the participants attended the regular PE classes (1 h, twice a week), learning team sports basics and acro-sports as topics. Two PE specialist teachers with expertise in nonlinear and linear approaches taught NLP and VLP, while the PE school teacher using constant linear pedagogy taught CLP. Figure 8 and Table 11 depict the rationale of the study, participants' grouping, and the pedagogies' features. In addition, all interventions and examples of the teaching approaches are provided in the “training” section and Annex 1.

Figure 8. Study's rationale and procedure. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy

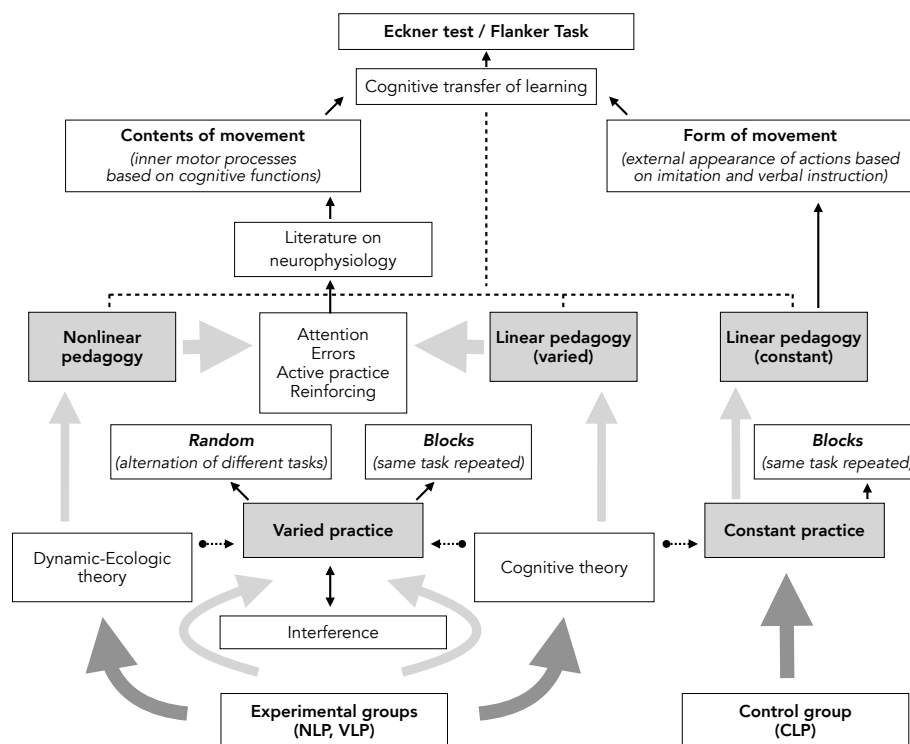


Table 11. Main features of the pedagogies used by the teachers

	NLP	VLP	CLP
<i>Theory</i>	Ecological	Cognitive	Cognitive
<i>Procedure</i>	Mainly focused on the movement's content	Mainly focused on the movement's content	Mainly focused on the movement's form
<i>Pedagogical approach</i>	nonlinear	linear	linear
<i>Teaching styles</i>	Productive: guided discovery	Reproductive: self-check, reciprocal style	Reproductive: prescriptive
<i>Task</i>	multitask	monotask	monotask
<i>Attention</i>	Distributed to several elements	Focused on sensory perception and on a specific element at once	No specific requirements, limited to the necessary model's observation
<i>Teacher's leading</i>	Indirect	Direct/Indirect	Direct
<i>Activities</i>	(learner-centered)	(teacher/learner-centered)	(teacher-centered)
<i>Practice</i>	random	blocks	blocks

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

To check that the teaching approaches corresponded to the expected ones, a random selection of PE lessons for each group was observed. PE lessons were video recorded and subsequently analyzed using the instrument for identifying the teaching styles (IFITS) (Curtner-Smith, 2020). The testing procedures were repeated at the end of the experimental period.

4.2.3.2. *Testing Procedure*

4.2.3.2.1. Inhibitory Control

A modified version of the flanker's task was used to measure the participants' selective attention and inhibition control (Eriksen & Eriksen, 1974). First, participants had to detect the direction of the central arrow among the five that appeared on a computer screen as quickly and accurately as possible. Within two seconds, they had to press the A key on the keyboard when the target arrow was pointed to the left, and the L key when it was pointed to the right. They had to ignore the flanking arrows on each side, pointing towards the same or the opposite

direction of the target one, and representing a congruent (left: <<<< or right: >>>>) or incongruent (left: >><>> or right: <<><<) condition.

One hundred trials were presented (50 right and 50 left target arrows) with the same probability of congruent and incongruent conditions. For both congruent and incongruent conditions, the mean response time of the correct responses and response accuracy were considered for the analysis. The survey and experiments were implemented and presented online using the PsyToolkit platform (G. Stoet, 2010; Gijsbert Stoet, 2016).

4.2.3.3. *Simple Reaction Time*

Clinical reaction time was measured according to the methods of Eckner et al. [50] to assess the simple reaction time. Participants had to catch an apparatus composed of a wooden graduated stick (0 to 100 cm) having a weighted disk at its extremity as quickly as possible, as the examiner released it at random intervals. The participants sat with their dominant forearm on the table's edge. The examiner suspended the apparatus so that the weighted disk was aligned with the top of the participant's open hand. The distance the apparatus fell (in centimeters) was recorded in eight consecutive trials. The mean distance was afterwards converted to time, in milliseconds, using the formula $d = \frac{1}{2}gt^2$. Then, the average of times was considered as clinical reaction time (Eckner et al., 2009).

4.2.3.3.1. Video Analysis of the PE Lessons

For each experimental group, three PE lessons were randomly video recorded at the beginning, half, and end of the training period for a posteriori examination to verify the actual teaching approach adopted by a teacher during the classes. Specifically, the total time of activity, action time, resting time, reflection time, and duration of teaching styles were assessed three times and analyzed by three PE experts using the instrument for identifying the teaching styles (IFITS) (Curtner-Smith, 2020). The IFITS is a validated interval recording tool (Bryant & Curtner-Smith, 2009a; 2008; 2009b) that analyses what teaching style the teacher uses during the lesson and how long the teacher uses it (Mosston & Ashworth, 2008). Every 20 s, a rater identifies which teaching style the teacher uses and reports it on the IFITS coding sheet. The rater reports the total time (min) of each teaching

style and calculates the percentage of each of them for the total activity time. A more detailed description of the instrument is provided by Curtner-Smith (Curtner-Smith, 2020). Intra- and inter-rater reliability were assessed using the intraclass correlation coefficient (ICC). The experts had been previously instructed and trained for six hours in collecting data and operating using coding instruments. The outcomes of the video analysis are provided in Table 12.

Table 12. Analysis of the teaching styles used by the teachers during the PE lessons and details of the students' activity

	NLP min %	VLP min%	CLP min %	Intra-Rater reliability (ICC)	Inter-Rater reliability (ICC)
<i>Teaching Styles</i>					
Convergent	16.3 ± 0.9			0.99	0.84
guided discovery	(30.5 ± 0.1)				
Divergent guided	33.3 ± 0.7			0.99	0.80
discovery	(62.4 ± 0.1)				
Reciprocal		38.8 ± 2.5 (70.3 ± 0.2)		1.00	1.00
Individual-based	3.8 ± 0.1 (7.1 ± 0.2)	5.0 ± 0.3 (9.1 ± 0.1)	15.3 ± 0.7 (27.8 ± 0.3)	1.00	0.99
choice					
Self-check		11.3 ± 0.6 (20.6 ± 0.3)		0.99	0.87
Command			39.8 ± 2.4 (72.2 ± 0.3)	0.99	0.72
<i>Activity</i>					
Total time of activity	53.4 ± 2.8 (100)	55.2 ± 3.4 (100)	55.1 ± 3.2 (100)	0.99	0.81
Rest time	3.9 ± 0.3 (7.3 ± 0.1)	4.1 ± 0.3 (7.5 ± 0.1)	4.0 ± 0.2 (7.3 ± 0.1)	0.99	0.69
Time in action	36.5 ± 2.0 (68.3 ± 0.2) *	38.9 ± 2.6 (70.3 ± 0.4) *	46.5 ± 2.8 (84.4 ± 0.3)	0.99	0.99
Reflection time	13.0 ± 0.6 (24.4 ± 0.1) *	12.3 ± 0.9 (22.2 ± 0.3) *	4.6 ± 0.4 (8.3 ± 0.2)	0.99	1.00

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. For each teaching style and activity, the duration is shown as mean ± SD, with the corresponding percentage with respect to the total in brackets. Intra-and inter-rater reliability were calculated to assess the accuracy of the IFITS evaluation by video analysis. * p < 0.05 vs. CLP by post-hoc analysis with Bonferroni's correction after one-way ANOVA was performed between NLP, VLP, and CLP.

4.2.3.4. *Training*

Experimental and control groups participated in their regular PE classes as follows.

4.2.3.4.1. Nonlinear Pedagogy

The NLP group was taught using a nonlinear approach following the “divergent and convergent guided discovery style” by Mosston and Ashworth (Mosston & Ashworth, 2008) based on the dynamic ecological theory of motor learning (Button et al., 2021). Several features composing the specific topic of each lesson were simultaneously selected and experienced based on practice variations and randomization. Pre-requirements and not specific motor models for acro-sport and team sports skills rotated every ten to fifteen minutes. The attention to the skills was indirect, multitasked, distributed, targeted, and adapted. Changes to the environment, task, and organism constraints were made rather than to the technical execution of a defined movement model (Button et al., 2021). Therefore, the students were indirectly encouraged to use a varied practice, including reasoning and knowledge of their self-adaptation ability, to address the managed affordances (Table 11).

4.2.3.4.2. Varied Linear Pedagogy

The VLP group was taught differently using a reproductive teaching approach, corresponding to the “self-check” and “reciprocal” styles of the spectrum of the teaching styles by Mosston and Ashworth (Mosston & Ashworth, 2008). It was based on cognitive theory principles with varied practice. Team sports basics and acro-sports were subdivided into tasks experienced in varied block practice (using a monotasking approach). After being instructed by the teacher through detailed instructions and direct demonstrations, the students were asked to reproduce and practice each task in pairs, switching the roles of executor and observer every ten minutes. The teacher controlled and provided support, suggestions, examples, analyses of errors, and stimuli to self-correct the performance through contrasting practice (requiring right and wrong actions). Again, attention was focused on the task-specific technical execution.

Therefore, the varied practice of VLP was mainly based on observation, comprehension, reproduction of reference models, and perception of one's own body through contrasting situations that stimulate the kinesthetic sense (Table 11).

4.2.3.4.3. Constant Linear Pedagogy (Control Group)

The CLP group, acting as a control for the frequent use of the constant linear pedagogy in schools, underwent standard PE lessons promoting team and acro-sports. CLP was taught by the ordinary PE class teachers, who previously declared to follow a consistent linear pedagogy approach with their students. No requirements were made regarding his/her teaching approach, and no guidelines were given to him/her about how to address the learners' attention. However, the lessons were video recorded and subsequently inspected to ensure, as the analysis confirmed, that the adopted teaching styles did not resemble VLP or NLP approaches (Table 12).

4.2.3.5. *Statistical Analysis*

Data are shown as mean $\pm$ standard deviations. A Shapiro–Wilk test checked the normal distribution. A one-way analysis of variance (ANOVA) was utilized to check the potential differences between practice/teaching approaches at the baseline (pre). No significant differences were observed between varied and constant practice (using the Student's unpaired t-test) and between the three teaching approaches (using the analysis of variance—ANOVA) in the baseline (pre). To test whether the inhibitory control and simple reaction time were influenced by the practice/pedagogy used by the teachers during the PE period, we used two-factor ANOVA (i.e., time, practice/pedagogy) with repeated measurements of one factor (time) (two-way ANOVA RM). In case of significant interaction, Bonferroni's correction was used post-hoc for pairwise comparisons. To better interpret and discuss the results, effect sizes (ESs, as Cohen's d values) were calculated for the magnitude of the over-time changes (pre-post). The corresponding ES thresholds for trivial, small, moderate, and large effects were classified as <0.2 , 0.2 to 0.5, 0.5 to 0.8, and >0.8 , respectively. A further analysis was carried out to test potential differences sub-sequent to teaching practice and pedagogy. Therefore, we decided to proceed with the analysis by considering the changes after intervention with respect to before (delta, post-pre) as more directly

representing the outcomes of the interventions. The Student's unpaired *t* test was used to compare the deltas of varied and constant practice approaches. The one-way ANOVA, or the corresponding non-parametric test (Kruskal–Wallis), was used to compare the deltas of NLP, VLP, and CLP. In case of significance, a Tukey's post hoc analysis (or Dunn's multiple comparisons test, in case of non-parametric data) was used for pairwise comparisons. The level of significance was set at an α level < 0.05 . Statistical analysis was performed using GraphPad Prism version 7.00 for Windows (GraphPad Software, San Diego, CA, USA).

4.2.4. Results

Figure 9 shows mean $\pm$ SD of the response time of the congruent and incongruent condition of the flanker task before and after the 12 weeks of intervention (panels A and C), with delta values (panels B and D), for varied and constant practice. The two-way ANOVA RM revealed a significant interaction (time $\times$ practice) for the congruent ($p = 0.026$; $F(2, 80) = 5.08$) and incongruent condition ($p = 0.013$; $F(2, 80) = 6.36$) of the flanker task. The main effect of time and group were not significant for both congruent ($p = 0.50$; $F(2, 80) = 0.44$; $p = 0.99$; $F(2, 80) < 1$) and incongruent condition ($p = 0.49$; $F(2, 80) = 0.47$; $p = 0.60$; $F(2, 80) = 0.26$). Post hoc analysis showed that varied practice improved in both congruent ($p = 0.027$, $d = 0.42$, small) and incongruent conditions ($p = 0.014$, $d = 0.37$, small). On the contrary, constant practice did not improve from pre to post in congruent ($p = 0.55$, $d = 0.17$, trivial) and incongruent conditions ($p = 0.45$, $d = 0.17$, trivial). Comparing the effects of varied and constant practice on inhibitory control, varied practice induced larger improvements (pre-post variations, deltas) than constant practice, in both congruent ($p = 0.026$) and incongruent ($p = 0.013$) conditions. Table 13 shows mean $\pm$ SD of the response accuracy of the congruent and incongruent conditions of the flanker task before and after the 12 weeks of intervention, together with delta values, *p*-values and Cohen's *d* values derived from the pairwise comparisons. For clinical reaction time (Figure 10), no significant interaction (time $\times$ practice) was revealed by the two-way ANOVA RM ($p = 0.55$; $F(2, 80) = 0.34$), highlighting that the type of practice did not differently influence the clinical reaction time. Similarly,

the main effect of time ($p = 0.09$; $F(2, 80) = 2.78$) and group ($p = 0.169$; $F(2, 80) = 1.92$) were not significant. Varied and constant practice did not improve from pre to post in the clinical reaction time ($p = 0.11$, $d = 0.21$, small; $p > 0.99$, $d = 0.13$, trivial, respectively). No significant difference was found in pre-post variations (deltas) of the clinical reaction time between varied and constant practice ($p = 0.53$).

Figure 9. Inhibitory control evaluated by the flanker task, measured before and after 12 weeks of PE classes in varied and constant practice. Panels (A,B) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (C,D) show the re-sponse time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. Pre; # $p < 0.05$ vs. constant practice.

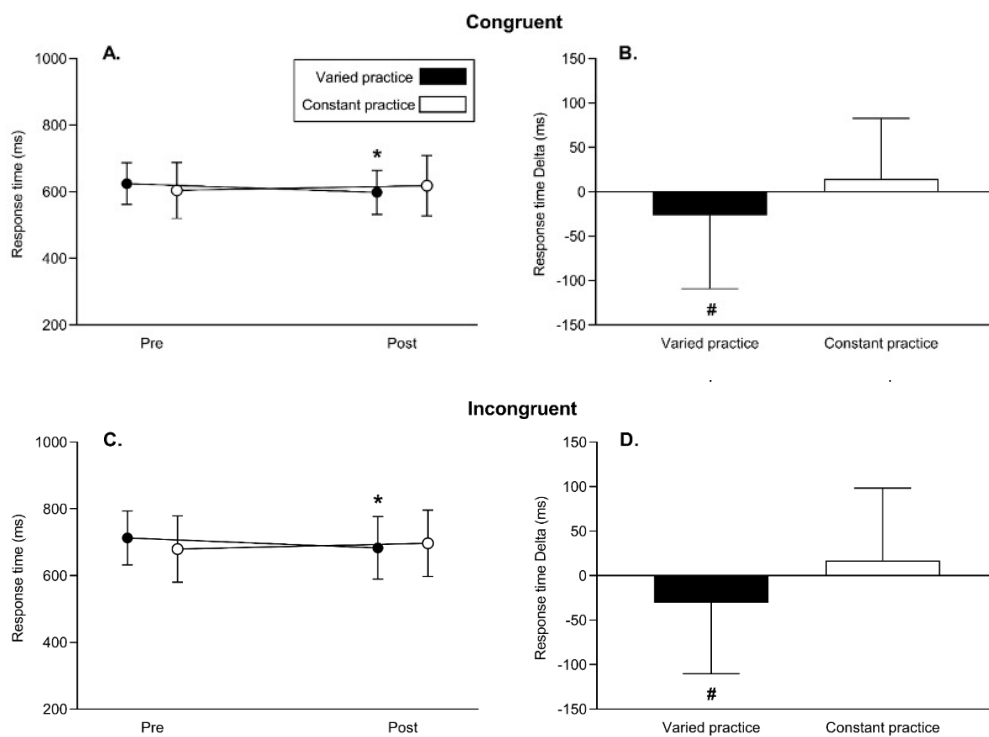


Table 13. Response accuracy (% of correct responses) in the congruent and incongruent condition of the flanker task in varied and constant practice.

	Time X Practice Interaction	Practice	Pre	Post	p-Value	Cohen's d ES	Delta (Post-Pre)
Congruent	$p = 0.012$; $F = 6.44$	Varied practice	87.7 ± 9.4	91.6 ± 9.1	91.6 ± 9.1	0.41 (small)	3.8 ± 12.7 #
		Constant practice	91.4 ± 13.7	85.9 ± 15.0	85.9 ± 15.0	0.40 (small)	-5.4 ± 20.5
Incongruent	$p < 0.001$; $F = 14.93$	Varied practice	85.9 ± 10.8	92.4 ± 7.8	92.4 ± 7.8	0.60 (medium)	6.4 ± 13.6 ###
		Constant practice	90.5 ± 15.4	81.6 ± 16.8	81.6 ± 16.8	0.57 (medium)	-8.9 ± 24.8

F-values with p-values of the time x practice interaction derived using the two-way ANOVA RM. Values are mean $\pm$ SD. p-values (by Bonferroni's correction) and Cohen's d ES refer to the pre-post comparison. * $p < 0.05$; # $p < 0.05$, ### $p < 0.001$ vs. constant practice.

Figure 10. Simple reaction time evaluated using the clinical reaction time (Panel (A)) and pre-post variations (Panel (B); delta, post-pre) measured before and after 12 weeks of PE classes in varied and constant practice.

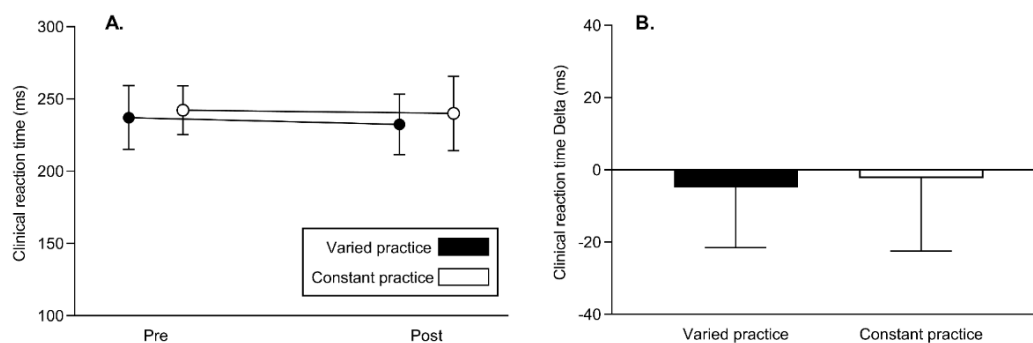


Figure 11 A, C shows mean $\pm$ SD of the response time of the congruent and incongruent condition of the Flanker task before and after the 12 weeks of intervention, for each teaching approach. The two-way ANOVA RM revealed a significant interaction (time x practice) for the response time of the incongruent condition ($p = 0.018$; $F(2, 80) = 4.19$) of the flanker task, whereas for the congruent condition, the interaction was not significant ($p = 0.066$; $F(2, 80) = 2.80$). The main effects of time and group were not significant for both the congruent ($p = 0.14$; $F(2, 80) = 2.20$; $p > 0.99$; $F(2, 80) < 1$) and incongruent condition ($p = 0.07$; $F(2, 80) = 3.32$;

$p = 0.18$; $F(2, 80) = 1.71$). When looking at the pairwise comparisons, teaching approach neither affected the response times of the congruent condition of the flanker task (NLP: $p = 0.07$, $d = 0.32$, small; VLP: $p = 0.67$, $d = 0.50$, moderate; CLP: $p > 0.99$, $d = 0.17$, trivial). Conversely, for the incongruent condition, only VLP improved from pre to post (NLP: $p = 0.11$, $d = 0.28$, small; VLP: $p = 0.007$, $d = 0.69$, moderate; CLP: $p = 0.22$, $d = 0.22$, small). Comparing the pre-post variations (deltas) in the response time for the flanker task between each teaching approach Figure 15 B, D, no significant difference was found for the congruent condition ($p = 0.066$, $F(2, 80) = 2.80$), whereas a significant difference was found for the incongruent condition for the flanker task ($p = 0.042$, $F(2, 80) = 3.28$). Specifically, VLP differed significantly from CLP, confirming the positive effects of this teaching method ($p = 0.044$), whereas no significant differences were found between NLP and VLP ($p = 0.86$) or CLP ($p = 0.14$). Table 14 shows mean $\pm$ SD of the response accuracy of the congruent and incongruent condition for the flanker task before and after the 12 weeks of intervention, with delta values for each teaching approach, together with p-values and Cohen's d values, derived from the pairwise comparisons. The clinical reaction time for each teaching approach is presented in Figure 12. No significant interaction (time $\times$ practice) was revealed by the two-way ANOVA RM ($p = 0.79$; $F(2, 80) = 0.23$), showing that the type of teaching approach did not differently influence the clinical reaction time. Similarly, the main effect of time ($p = 0.054$; $F(2, 80) = 3.81$) and group ($p = 0.084$; $F(2, 80) = 2.55$) were not significant. Clinical reaction time did not improve from pre to post in NLP ($p = 0.27$, $d = 0.21$, small), VLP ($p = 0.10$, $d = 0.22$, small), and CLP ($p = 0.51$, $d = 0.13$, trivial). No significant difference was found in the pre-post variations (deltas) of the clinical reaction time between the three teaching approaches ($p = 0.26$; $F(2, 80) = 1.77$).

Figure 11. Inhibitory control as measured by the flanker task, measured before and after 12 weeks of PE classes using nonlinear pedagogy (NLP), varied linear pedagogy (VLP), and constant linear pedagogy (CLP). Panels (A,B) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (C,D) show the response time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. pre; # $p < 0.05$ vs. CLP.

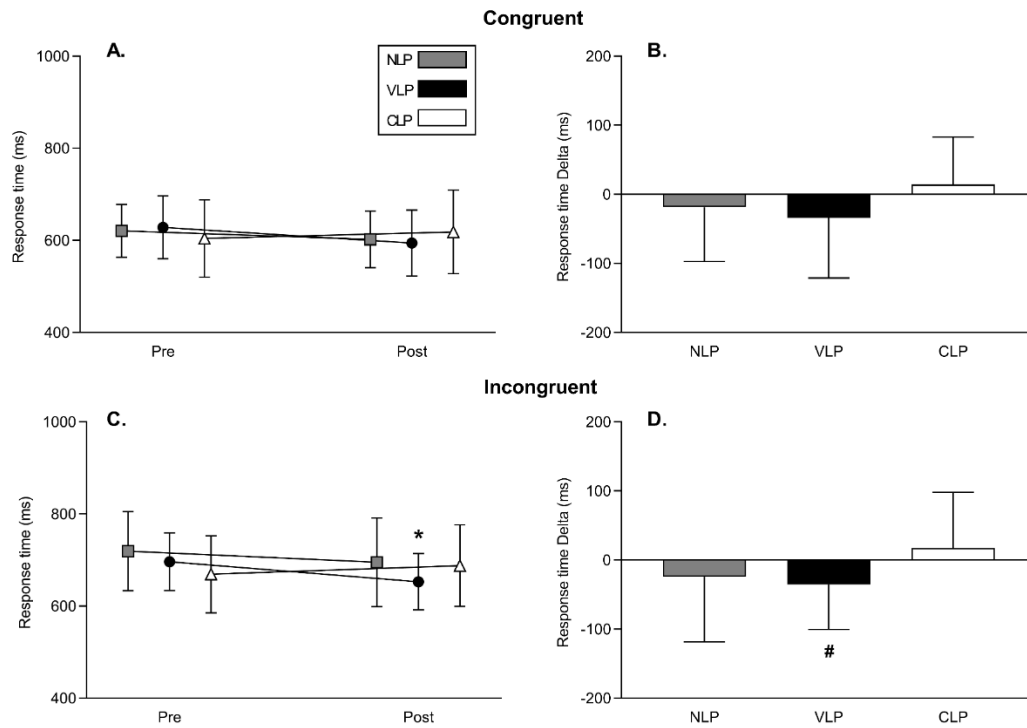
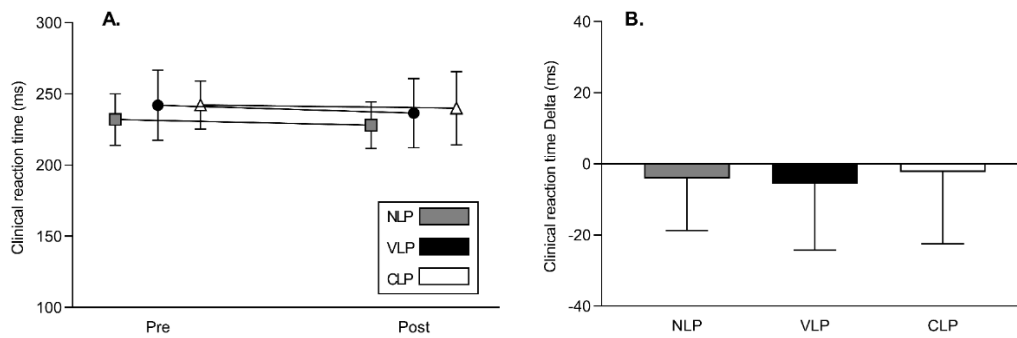


Table 14. Response accuracy (% of correct responses) in the congruent and incongruent condition for the flanker task for NLP, VLP, and CLP

	TimeXPractice Interaction	Group	Pre	Post	p-Value	Cohen's d ES	Delta (Post-Pre)
Congruent	$p = 0.048$; $F = 3.09$	NLP	86.7 ± 8.8	90.4 ± 7.3	0.686	0.42 (small)	3.6 ± 11.5 #
		VLP	88.7 ± 10.1	92.8 ± 10.5	0.669	0.36 (small)	4.1 ± 14.0 #
		CLP	91.4 ± 13.7	85.9 ± 15.0	0.208	0.40 (small)	-5.4 ± 20.5
Incongruent	$p < 0.001$; $F = 7.74$	NLP	84.8 ± 9.3	89.7 ± 7.2	0.384	0.53 (medium)	4.9 ± 11.2 #
		VLP	87.1 ± 12.2	95.0 ± 7.6	0.049 *	0.66 (medium)	7.9 ± 15.7 ##
		CLP	90.5 ± 15.4	81.6 ± 16.8	0.018 *	0.58 (medium)	-8.9 ± 24.8

F-values with p-values of the time x practice interaction derived by the two-way ANOVA RM. Values are mean ± SD. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. p-values (by Bonferroni's correction and Cohen's d ES refer to the pre-post comparisons. * $p < 0.05$; # $p < 0.05$, ## $p < 0.01$ vs. CLP.

Figure 12. Simple reaction time evaluated using the clinical reaction time (Panel (A)) and pre-post variations (Panel (B); delta, post-pre) measured before and after 12 weeks of PE classes for NLP, VLP, and CLP. NLP: nonlinear pedagogy; VLP: varied linear pedagogy



4.2.5. Discussion

To investigate the role of type of practice and teaching approach on cognitive improvements related to PE, we tested inhibitory control and reaction time in preadolescents before and after a 12-weeks PE period taught using different teaching approaches (e.g., the varied practice of linear and nonlinear pedagogy and constant practice of linear pedagogy). Varied and constant practices induced different outcomes in the flanker task for inhibitory control and response time.

Two notable results were reported in this study. First, 12-weeks of PE based on varied practice induced superior benefits on inhibitory control (response time and accuracy of the flanker task) compared to constant practice. Second, VLP provided greater improvements in inhibitory control (response time of the incongruent condition of the flanker task), compared to NLP and CLP, which showed no significant changes.

Together, these results showed that varied practice, characterizing both NLP and VLP, showed greater improvements in inhibitory control than CLP. Contextual interference literature showed that diversification of the proposals allows a greater motor program elaboration (Bortoli et al., 1992) and a better stimulation of executive functions, with a better transfer capacity related to inhibition/self-regulation (Diamond & Lee, 2011), as shown in our study.

Furthermore, reflection time was higher in NLP and VLP than in CLP (Table 3). Reflexive approaches of NLP and VLP stimulated metacognitive processes and

greater awareness, which led to a better transfer in cognition (Bransford et al., 2000).

On the other hand, the time in action in VLP and NLP was lower than in CLP. We can assume that the better results in inhibitory control in VLP are due to the quality of re-flection and the cognitive processes activated through a reflexive practice, not for the quantity of practice (Bransford et al., 2000; Dietrich, 2004).

Thus, varied practice within a nonlinear approach encourages new arrangements and increases the ability to adapt the learning outcomes to different situations (Chow et al., 2020). This approach relates to an incorporate cognition view (Egger et al., 2019), in which brain activation (Koziol et al., 2012) and cognition depend on action, and it is founded on perception-motor interaction (Engel et al., 2013). Linear pedagogy assumptions of VLP are different from those of NLP and consider variations to solve errors through contrasting situations stimulating the kinesthetic sense. In fact, situational difficulties raise efforts to address the requests, favoring body awareness and enhancing transfer learning (Ávila et al., 2012; Wormhoudt et al., 2017; Wulf et al., 2002). Teachers who use this approach encourage students to overcome difficulties by focusing their attention on relevant fundamentals for success and inhibiting their intuitive, quick, and less-reasoned responses (Ávila et al., 2012).

Moreover, in contrast with a constant practice of the CLP protocol, approaches based on variations allow the learner to self-evaluate tasks and plan outcomes (Sierra-Díaz et al., 2019). The fact that a varied practice of our protocol has improved performance in the flanker task supports that pondering and reflecting, by stimulating proficiency and motor creativity, can speed up the learning process and improve executive functions, such as inhibition (Zelazo, 2015). Therefore, frequent assessments and learning strategies based on context design and environmental changes are suggested to overcome the comfort zone (typical of constant practice), thus better promoting learning and supporting cognitive development.

The results of our study are based on the fact that qualitative, non-automatic demands activate the same regions of the brain that are used to control other cognitive aspects. The alert attentiveness created by variations and active involvement, based on the situations proposed, activate the reactivity and vigilance of the cortex (Pesce, 2012; Tomporowski & Pesce, 2019). We also tested whether a

linear pedagogy induced more benefits than nonlinear pedagogy within the varied practice approach. The literature returns contrasting results, both supporting linear or nonlinear pedagogy (Chow et al., 2020; Renshaw et al., 2010; Rudd et al., 2020). The latter promotes motor learning through benefits from embedded attentiveness and concentration enhancement, integrating perception and action (Gibson, 2014). The NLP protocol (Table 11 and Annex 1) was based on the ecological dynamics theory (Calvo & Gomila, 2008). Conversely, the monotasking approach of VLP had superior learning effects because of the prefrontal cortex activation, which reduced errors by focusing attentiveness on a single task (Kouneiher et al., 2009). Indeed, when looking at the pre-post comparisons, NLP showed a similar trend to VLP, albeit not significant ($p = 0.11$, $d = 0.28$, small), while CLP demonstrated a clear opposite trend (see the delta comparisons in Figure 14). These considerations may support the nonlinear pedagogy approach for cognitive improvement. However, VLP improved inhibitory control compared to NLP and CLP (Figure 14), which suggests that the VLP approach seems to be the most effective method for cognitive development in response to PE.

Referring to the results, active learning, based on students' autonomy and accurately guided by the teacher (VLP), is the most efficient approach in cognitive transfer situations for 12-13 years old children. Curiosity is the key element that determined a better attentiveness and executive functions in VLP approach. Curiosity refers to what the children think is useful to learn. In the same way that an activity that is too repetitive is not attractive, neither is a practice that is too confusing (Dehaene, 2020) or little related to specific goals.

The error plays a fundamental role in VLP. In fact, the brain can compare what has been predicted through the motor program and the outcome. Mental representation can be revised by referring to the prediction error (Dehaene, 2020). When a prediction error occurs, it engenders surprise in the performer because of a violation of his expectations (Rescorla, 1972). This would support specific psycho-emotional and cognitive processes indispensable for a learning transfer.

It is interesting to note that clinical reaction time was the only variable not affected by the different types of practice and teaching approaches. An explanation for the lack of improvement in the clinical reaction time can be related to the fact that this test assesses simple reaction time. There is evidence showing that physical activity is related to cognitive performance requiring a high level of attentional control in a

complex reaction time task (i.e., incongruent conditions with flanking information) (Hillman et al., 2006) more than in a simple reaction time task (such as clinical reaction time). Moreover, according to Posner (Posner, 1978), rapid hand reaction movement improvements would have been expected. It is plausible that more than 12 weeks of varied intervention training are necessary to integrate elaborative processes with neuromotor actions and then to discriminate improvements in this type of reaction time.

Some limitations should be acknowledged. The NLP approach was based on pre-requirements and not on specific motor models. Therefore, no motor tests were chosen for assessing acro-sports and team sport game competencies to compare the different pedagogies in which learning processes were centered. Further investigation on tasks, ages, sex, and expertise are needed to examine the effect of variability on transfer.

Practical Applications and Sustainability

Based on the results, PE teachers should provide lessons featuring learning based on reflection and varied practice. In particular, the learning should be characterized by: (a) the explanation of the usefulness and aims of the exercise; (b) the use of appropriate integrated methodology such as problem-solving, guided discovery, self-check, and reciprocal methods. These approaches can precede, be simultaneous with, or follow the practice and can be proposed before, during, or after the activity (Rink, 2010). They could represent a concrete method to educate students to fit into present society.

The increasing complexity of modern society, the continuous innovations, and the consequent socio-cultural changes require quality teaching to guarantee the social utility of the learning (Bentley, 1998; Wright et al., 2004). The need for sustainable and quality teaching deals with the purpose highlighted by the 2030 Agenda of Sustainable Development Goals of the United Nations (United Nations, 2015). Among the various points covered, the document evidences the need to “ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles” (United Nations, 2015)

Hence, in PE, sustainable and quality teaching should satisfy the broader need for the flexible adaptation to different contexts, promoting and developing social

usefulness, and a lifetime of “good practices” pursuing long-term physical literacy (Whitehead, 2010). In learning processes, teaching styles such as problem-solving, reciprocal, self-check, and inclusion methods could be helpful to promote engagement through active reflection and encouraging students to explore different and new solutions (Lutze-Mann, 2014), gradually inducing them to interact with and fit into a constantly changing society.

4.2.6. Conclusions

The present study revealed that 12 weeks of PE based on varied practice improved inhibitory control more than did constant practice. The current findings also showed how a VLP better improved inhibitory control than either NLP or CLP. From a practical perspective, NLP and VLP may be preferable approaches for enhancing executive functions in preadolescents. However, VLP seems to be the most effective approach within PE classes aimed to improve cognition. Promoting PE lessons based on VLP might contribute to fostering targeted and individualized learning strategies, interdisciplinarity, metacognition (self-perception skills), and intrinsic motivation in school-age individuals.

4.3. THE “THINKING SYSTEM” IN A NEW SCHOOL CONCEPT: A RHYTHMIC TEACHING APPROACH IN PHYSICAL EDUCATION TO DEVELOP CREATIVITY

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4.3.1. Abstract

System Thinking is an actual construct supported by several scientific evidence that offer a perspective on how phenomena relate. Rhythm methodology, teaching-learning, and enjoyment in physical education are the main system elements we hypothesize interacting closely to determine direct or mediated effects on motor creativity and rhythmic perceptive capacity. Seventy-six elementary and middle school students (8.9 ± 2.1 years) were randomly assigned to two groups: a) an intervention group that received a physical education lesson based on rhythmic methodology and b) a control group that received conventional lessons without specific rhythmic interventions. Participants were engaged in eight physical education lessons lasting one hour each for eight weeks. Tests and questionnaires were administered before and after the intervention to evaluate motor creativity, rhythmic perception capacity, self-perception and enjoyment. Two lessons were randomly analyzed to identify the teaching style and motor content (moderate and vigorous activity). The main results revealed direct effects on the intervention group's motor creativity ($p = 0.001$) and its rhythmic perception capacity ($p = 0.02$). Furthermore, enjoyment mediated the effects of the intervention on motor creativity ($p = 0.01$). Finally, the results have shown that self-perception does not mediate the effect of rhythmic intervention group on motor creativity and rhythmic perceptive capacity ($p > 0.05$). A rhythmic methodology proposed by specific multi-teaching styles can involve children and young people in an enjoyable activity with more moderate to vigorous physical activity.

4.3.2. Introduction

4.3.2.1. *Thinking system and scholastic vision*

A thinking system approach considers complexity as an intrinsic element of every change process, and this can be extended even to a formative path. This topic addresses a growing interest related to the community of practice and the connection with other elements that can be functional in managing educational policy in real contexts. The thinking system approach encompasses emerging ideas

and methods that promote the exploration of the most comprehensive framework, encouraging one to look at the bigger picture (De Savigny & Adam, 2009; Meadows, 2008; Sterman, 2006). Thinking system can be traced back to three keywords: interrelation, as the connection between the elements of the system; multiple vision, as an approach to the issue that considers different viewpoints and perspectives (as qualitative and quantitative research with the use of mediators and moderators); boundaries, which delimited the interconnected elements and what is external to this system of interests. Literature has already shown a multi-faceted integrated system approach (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007; Trecroci et al., 2023).

The framework proposed in a previous study is an example of how the formative system results from a complex relationship of many integrated domains, with different points of view and some elements found inside and outside the system of interest (Trecroci et al., 2023).

This way, to embrace an integrated and complex vision, the school is increasingly oriented towards a transdisciplinary approach that reflects the thinking system. The interrelation of several disciplines promotes a learning system based on a multiple vision, in which each discipline while maintaining its identity and characterizing elements, i.e., its boundaries, can also lead to other subjects enriching the learning process (i.e., music and physical education to improve on rhythm and motor creativity). Disciplines should not be presented as territories to be protected by defining rigid boundaries but as interpretive keys available for every possible use. Complex problems require different disciplinary viewpoints to dialogue with each other and to pay attention to the border and hinge zones between disciplines (MIUR, 2012)

4.3.2.2. *Rhythmic training and systemic view in scholastic context*

The ability to sequence is very important in children's learning process. Rhythm-based practice in school settings enables children to acquire good

temporal and rhythmic perception, which are essential for learning reading, writing, and language skills (Haines, 2003). In a systemic view, the interrelation of music and physical education, through rhythmic perception and motor creativity improvement, can enforce the learning of reading, writing, and language skills in a multiple-vision concept (Anic et al., 2018; Bashwiner & Bacon, 2019; Haines, 2003; Wolff, 2002). In music, rhythm is the most important structural element. The music domain is organized into temporally structured sequences. It is composed of rhythmic structures that underlie an important organization of temporal successions (Patel, 2010). Its metric organization is similar to linguistic syntax. Sensory-motor integration, motor control, and action planning can be analyzed through rhythmic syntax (London, 2012). It is common to see how movement can be easily integrated within a musical environment through dancing, tapping, or nodding one's head to follow the rhythm. In more complex situations, two or more people interact during musical activity, playing and dancing together (Phillips-Silver & Keller, 2012), and in social contexts, individuals act concurrently. Rhythm denotes a quality aspect of movement. More specifically, rhythmic movement in physical education considers a structured sequential form to utilize for favoring the acquisition of motor skills or expressions movements as manifestations of mental, social, and emotional responses (Vazou et al., 2019).

4.3.2.3. *Creativity in scholastic thinking system*

Creativity must be considered a process incorporated in the cultural sphere of reference (Beghetto & Kaufman, 2014).

Creativity represents an act, an idea, that is produced in a particular field or that, starting from an existing field, generates a new one. Symbolic elements and specific notation systems mediate the knowledge expressed in the creative act. Each domain follows specific and rigid rules that limit its nature, modes of expression, and accessibility (Csikszentmihalyi, 1997). Creativity understood as a system must consider three components (Csikszentmihalyi, 1997; Parlamento Italiano, 2018):

The domain, made up of the specific symbolic rules and procedures that make up its structure. The domain referred to in this study consists of scholastic physical education and, with a finer concept analysis, in motor creativity.

The field, which refers to "the custodians" of the domain through which the possibility of including a new idea and didactic path is considered. The field in the school environment directly involves the teachers of the disciplines

People directly involved in the didactic-creative action (schoolchildren), and who, using the symbols of a domain, learn to express and identify a new pattern

Creativity in a specific domain has boundaries that determine what content can be included and what should be excluded. This way, transversality is a modality that can be used to grant new skills through the opening to accessible and related domains.

The efficacy of the choice of a related domain must be based on the criteria of clarity and simplicity of the new structure, its accessibility, and its possible recognizable presence in the main domain.

Transversal and transferable skills through the operational dimension of doing (as in the context of connection between rhythm and movement) can include new processes of critical thinking forming the basis of the creative domain of PE. These processes involved motricity and stimulated a new type of reflective and internalized learning that plays an essential role in self-construction, in which the student is an actor in his or her skills and knowledge acquisition (Parlamento Italiano, 2018).

Developing creativity in children is important to let them express themselves through the art of music and body expression. The student's proficiency in these multi-perspective skills can significantly impact their attitude, strategies' effectiveness, interpersonal interactions, and ability to gather and utilize feedback for adapting and improving actions across the considered domains (Parlamento Italiano, 2018). In this regard, it becomes important that the context provides many possibilities for acquiring, memorizing, internalizing, and reproducing the stimuli of the different integrated domains. The school must develop integrated

educational action to foster connections between relational domains and domains involving teachers who, in a transversal approach, follow a common path of intervention (Parlamento Italiano, 2018).

In this process, physical education and rhythm are the elements of the system that are considered within and beyond the interest in developing critical thinking processes. In particular, rhythm is conceived as a point in a system that can produce broad changes in motor creativity (leverage point) (Clarke et al., 2020).

Added value by considering a comprehensive set of factors influencing motor creativity (understanding the complex drivers that can foster learning)

A. Factor 1: Teacher and motor creativity.

Although the students occupy a central position in their learning process, the teacher also plays a crucial role in success. The teacher acts as an artist who has to shape his opera, referring to the context. He or she must create proper transdisciplinary pathways to achieve the transversal competencies. The teacher plays a key role in this complex system: through proper teaching practice, he/she can influence the students to learn and improve in a specific field. School autonomy (Presidente della Repubblica, 1999) lets the teacher find strategies peculiar to the context to ensure their attainment of competencies at the end of the education cycle. The teacher is responsible for employing an integration teaching style related to the context (MIUR, 2012). Several studies highlight a relationship between the teacher's ability to vary the use of different teaching styles and the involvement of cognitive, motivational, motor, and emotional aspects essential for maintaining an interest in developing creative-motor skills (Invernizzi et al., 2019; Yap, 2021).

Not surprisingly, an integration of several teaching styles allows for better creative thinking outcomes than a classical linear approach. Such an approach stimulates the student to find more personal solutions through continuous exploration of different and creative motor behaviors and flexible use of attention

to solve environmental problems. Furthermore, through teaching styles that stimulate a maieutic and collaborative process, he or she can help the student develop his or her soft skills, which are indispensable for building the relationship with the teacher himself or herself and on which the outcome of the learning process depends (Invernizzi et al., 2022; Invernizzi & Scurati, 2019). The teacher's task is to encourage motor activity within the educational process.

He or she can successfully achieve this goal through rhythm-based practice, offering age-appropriate qualitative and quantitative stimuli. Music, by its nature (temporal scansion and succession, structure, rhythm, sequencing), facilitates and makes the approach to motor practice almost spontaneous. A multi-teaching approach involving music, physical education, and creativity could enhance the learning process (Nijs, 2019).

The relationship between music, movement, and creativity can be explained by the intervention of the primary motor cortex M1, which appears to mediate the potential for creative motor action associated with a pre-planned creative idea. The basis for a creative idea may form in brain areas associated with higher-order creative processes and then flow in part through M1 and be realized as a creative motor action (Anic et al., 2018).

In addition to the teacher's ability to establish relationships with his or her students, the ability to elicit enjoyment also plays a crucial role in the learning process (Frenzel et al., 2009).

B. Factor 2: Enjoyment and motor creativity.

Enjoyment is a positive psychological effect that reflects happiness, pleasure, enthusiasm, liking, excitement, and fun (Burns et al., 2017). In physical activity, enjoyment represents a positive attitude toward practice and is one of the most important aspects of motor development and sports participation (Lubans et al., 2008).

Adequate levels of enjoyment and self-perception of physical fitness increase motivation, engagement, and participation in physical activity (Borrego-Balsalobre et al., 2023). Pleasant and fun motor experiences in varied contexts are crucial for acquiring adequate bodily self-awareness in children and young people (Ramer et al., 2021).

C. Factor 3: Motor creativity and self-perception.

Assiduous participation in physical practice makes it possible to acquire and consolidate new motor patterns and increase motor competence in the long run. Children with a high level of motor competence are more likely to have an active lifestyle that positively influences physical and mental well-being (Robinson et al., 2015). Motor competence relies on its specific and highest manifestation in motor creativity, a perceptual ability that favors the development of new motor patterns aimed at solving problems or as body expression of ideas and emotions (Bournelli et al., 2009). Motor creativity enables the production of motor movements and gestures to solve specific motor tasks or express emotion physically (Bournelli et al., 2009; Richard et al., 2018).

Compared to motor competence, motor creativity develops more through exploratory teaching in an environment with well-adapted constraints, where kinesthetic variety is supported and where everyone is free to experiment through movement (Renshaw et al., 2009; Richard et al., 2018). Varied and positive kinesthetics and motor experiences improve the self-perception of children and young people by promoting the awareness of successfully acquiring different motor skills (Bandura, 1997). This capacity for self-perception is linked to the cognitive, motor, and social resources that the subject can mobilize in the different contexts in which he/she must produce motor skills (Robinson et al., 2015). The quality of experience provided by the teacher through effective teaching processes increases the positive self-perception capacity of young people (Dapp & Roebbers, 2019; Khodaverdi et al., 2016).

4.3.3. Research questions

Two research questions can be posed considering the following premises and the complexity of the thinking system approach in the school system. Does a skilled teacher using rhythm-based activities and appropriate challenges help students become more creative in their movements and better at recognizing rhythms? Also, how does the enjoyment of the activities, feeling competent, and age influence this learning process?

4.3.4. Materials and methods

4.3.4.1. *Participants*

Seventy-six elementary and middle school students were voluntarily recruited (from the 12th to the 19th of September 2022) for our study. Thirty-two students were in the second year of elementary school (2nd elementary school), twenty were in the fourth year of elementary school (4th elementary school), and twenty-two were in the third year of middle school (3rd middle school). Thirty-six participants were males, and forty participants were females. The students were divided into an experimental (section A) and a control group (section B), utilizing a class-randomized procedure. In this study, the experimental group underwent a rhythm-based intervention (RI), while the control group did not receive any rhythm-based intervention (NI). Participants' demographics are shown in Table 15. All participants and their parents were informed about the purpose and experimental protocol of the study. Parents or legal guardians provided written informed consent before the investigation. Following the Declaration of Helsinki, the study was approved by the Ethics Committee of the local University (approval number 18/22).

Table 15. Participants' demographics

Group	Male	Female	n	Age (years)	Height (m)	Weight (kg)	BMI (kg/m ²)
RI	21	22	43	9.02 $\pm$ 2.03	1.38 $\pm$ 0.16	35.00 $\pm$ 12.53	17.53 $\pm$ 2.87
NI	15	18	33	8.84 $\pm$ 2.22	1.38 $\pm$ 0.17	34.63 $\pm$ 13.3	17.60 $\pm$ 2.94

Data are mean $\pm$ SD; RI = Rhythm Intervention; NI = No-Rhythm Intervention. BMI = Body mass index.

4.3.5. Measures

4.3.5.1. *Rhythmic perceptive capacity*

Mira Stambak test was employed to assess the rhythmic perceptive capacity. Stambak's test evaluates spatiotemporal structure by testing the rhythmic ability on multiple levels as a replication of temporal structures: the evaluator plays twenty rhythmic sequences in which each circle corresponds to a beat, and each space corresponds to silence. The child had to reproduce it respecting the beating and resting time; symbolization of spatial: the evaluator shows ten rhythmic structures one by one. After showing a structure for a few seconds, the examiner hid it from the participant. The participant had to memorize the structure and reproduce graphically each sequence; symbolization of temporal structures: the examiner reproduces the rhythmic structures by tapping. After listening, the participant had to write the sequence respecting circles and spaces. In each task, after two consecutive incorrect sequences, the test ends. A point is obtained when each successful structure is performed, and, in the end, the points obtained for each level are added (Stambak, 1951). Since 1951, Stambak's test has been used in different fields and research demonstrating its validity and reliability (Dellatolas et al., 2009; Stambak, 1951; Trecroci et al., 2023).

4.3.5.2. *Motor creativity*

Divergent Movement Ability (DMA) test was performed to investigate motor creativity in school-aged children. The DMA's validity and reliability were previously established (Cleland, 1994). No warm-up was done before performing the test. DMA measures the fluency and flexibility dimensions of creativity of three

dimensions of movement skills: locomotor, for which an individual is asked to use the tools provided (e.g., two mattresses of different sizes, four cones arranged diagonally, a suspended rope, and a hoop supported by three cones) stimulating them to create as many movements as possible; stability, for which an individual is free to take on different figures (with their body parts) within an area with a 45.5 cm high bench placed in the middle; manipulation, for which an individual handles a ball (23 cm diameter) within an area (3 m × 4.5 m) delimited by cones (on three sides) and a wall (on the last side). Participants were tested on their ability to manipulate the ball. They were constantly motivated to provide as many solutions as possible. The examiner provided no feedback about their performance. Two-time trials were given for each skill with the following arrangements: 90 s for each trial with a 60-s resting period in between. Then, 120 s of rest were given between each dimension of fundamental movement skills. Each student was video recorded, and results were evaluated using video analysis. The score is composed of the number of solutions the student performs for each dimension of movement skills. A total score was assessed, summing score obtained in locomotor, stability, and manipulative areas (Cleland, 1994).

4.3.5.3. *Enjoyment*

Enjoyment was recorded using the Italian version of the Physical Activity Enjoyment Scale (PACES) (Carraro et al., 2008). PACES questionnaire included 16 items classified into a 5-point bipolar Likert Scale (1=totally disagree; 2=disagree; 3=not sure; 4=agree; 5=totally agree). A high score of positive items and a low score of negative items is related to high enjoyment. A total score can be calculated by reversing and adding the negative item score to the positive item score. The validity and reliability of the Italian version was investigated by Carraro and colleagues (Carraro et al., 2008).

4.3.5.4. *Self-perception*

4.3.5.4.1. Self-efficacy

The Italian version of the Physical Self-Efficacy Scale (PSES) (Colella et al., 2008) was employed to evaluate Self-efficacy in year four elementary school students and in year three middle school students. PSES is structured into six items having a 1- to 4-point format scale. Students had to think about themselves when performing physical activity, and for each item, they had to choose the sentence that closely represents their performance. The total test is 1-24 scored. The higher the score, the higher the self-efficacy. The validity of the Italian version was investigated by Colella and colleagues (Colella et al., 2008).

4.3.5.4.2. Perceived motor competence

To measure the self-efficacy in the second-year elementary school students, the Pictorial Scale of Perceived Movement Skill Competence for Young Children (PMSC-2) (Barnett et al., 2015) was used, instead of PSES. Indeed, according to previous studies (De Meester et al., 2020; Estevan & Barnett, 2018), self-efficacy, self-perception, perceived motor competence are related. PMSC-2 is structured with four graphical representations of the process of the movement. For each skill, students must think about how to perform the movement and choose images that best fit their thinking. The validity and reliability were established by Barnett and colleagues (Barnett et al., 2015).

4.3.5.5. *Video analysis*

The video analysis was conducted through the System for Observing Fitness Instruction Time (SOFIT) (McKenzie et al., 1992) and through the Identifying the Teaching Styles (IFITS) (Curtner-Smith, 2020). Two out of eight lessons were randomly selected and recorded in both groups. The analysis was evaluated by some Physical Education (PE) experts using SOFIT to calculate the quantity of physical activity during each lesson and IFITS to evaluate the quality of physical activity in terms of the teaching style used. The data resulting from IFITS and

SOFIT analysis were resumed and compared in the two groups as percentages. For both IFIT and SOFIT procedures, lessons were coded simultaneously by two independent observers using the same sampling pace. One of the two observers was considered the lead observer, and his data were considered for the analysis, while the second represented the reliability observer. Moreover, both observers performed the evaluation twice, distanced by a week.

Intra- and inter-rater reliability of SOFIT and IFITS was assessed using the following formula:

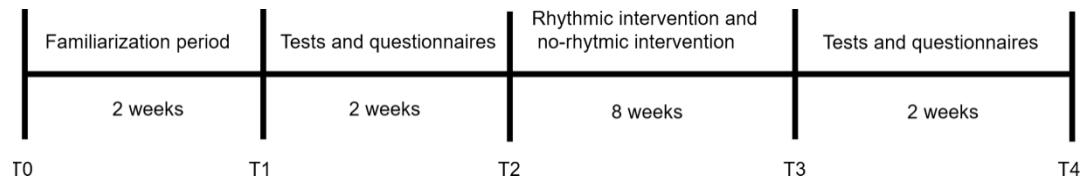
$$R\% = (n^{\circ} \text{ of agreement} / (n^{\circ} \text{ agreement} + n^{\circ} \text{ disagreement})) * 100.$$

The intra and inter-rater reliability was considered valid if the percent of agreement (R%) overpassed the 80% (Cleland, 1994). The same procedure of reliability was performed for the DMA valuation.

4.3.6. Procedures

The experimentation was led during PE classes, using the gym to perform the tests and the rhythmic and standard lessons, and the classrooms to complete the questionnaires. Anthropometric measures of height and weight were recorded to the nearest 0.1 cm with a standing stadiometer (Seca 217, Basel, Switzerland), and weight was measured to the nearest 0.1 Kg with a high-precision mechanical scale (Seca 877, Basel, Switzerland). Body mass index (BMI) was calculated as the ratio of body mass to height squared. Before testing the participants, a familiarization period was led. The two-week familiarization period included testing sessions for motor creativity and rhythmic perception. Both DMA and Mira Stambak's tests were repeated twice for reliability. The experimental tests and the questionnaires related to enjoyment and self-perception were performed after the familiarization period. The experimental session was carried out after the tests' performance and the completion of questionnaires. Eight rhythmic lessons, lasting one hour each, were conducted for the RI group, and eight no-rhythmic lessons were conducted for the NI group. The same PE teacher led the lessons. Two of eight lessons were recorded randomized, with a camera, and the videos were analyzed successively by a PE expert. At the end of the experimental period, tests and questionnaires were repeated. The experimental timeline is shown in Fig. 13.

Figure 13. Overview of the experimental timeline



4.3.6.1. *Content of the lessons*

The lessons were led by an expert PE teacher who worked in elementary and middle school for four years and cooperated with the University of Milan in both groups, interacting with the school's music teacher. The 2nd elementary school RI group students attended lessons focused on rhythm perception using music, listening, discovering, and inventing rhythmic sequences with gym equipment. They worked individually, in pairs, and small groups. On the other hand, the 2nd elementary school NI group students attended lessons focused on topological and Euclidean space perception. They worked individually, in pairs, and in small groups as well. The 4th elementary and 3rd middle school RI group students attended lessons focused on rhythm in team sports such as basketball and handball, playing with music, following the rhythm of the music, or discovering rhythmic sequences in the technical skills. The 4th elementary and 3rd middle school NI groups attended lessons focused on team sports without taking care of rhythm perception but focusing on technical aspects, tactical strategies, and rules. Both groups worked individually, in pairs, and small groups. In the 2nd elementary school classes, we used most rhythmic cadence in 4/4 and few kid's songs as "Super simple songs for kids". In the 4th elementary and 3rd middle school classes we used rhythmic cadence in 4/4 as well and we choose songs from 100 (for technical aspects as bouncing, passing the ball, basketball and handball running shots) to a maximum of 140 bpm (for the musical fitness lessons only in the 3rd middle school). In 140 bpm songs we used a halved rhythm for marching or running on the spot, high knees, and toe touch, one movement every 2 quarters for squats and lunges.

4.3.6.2. *Statistical analysis*

The Shapiro-Wilk normality test and kurtosis/skewness analysis (Kim, 2013) were performed to assess the normal distribution of the data. Data are shown as mean $\pm$ standard deviation (SD). The reliability of DMA and Mira Stambak's tests was performed using the Intraclass Correlation Coefficient (ICC). The two-way Anova Time $\times$ Intervention (with repeated measures on time) was performed to investigate the intervention's effects on creativity and rhythmic perceptive capacity. The significance level was set at $\alpha = 0.05$ while the effect sizes were calculated as eta squared (η^2), using the small = 0.01, medium = 0.06, and large = 0.14 interpretation (Cohen, 2013). In addition, a multiple regression analysis was performed to obtain information about mediators and moderators. The mediation analysis was performed by Baron & Kenny's method following criteria for establishing mediation in which the independent variable (IV) is the intervention, the dependent variable (DV) is the main outcome, and the mediator is the variable controlling the IV-DV relationship. The mediation models were structured by placing intervention as IV, rhythmic perceptive capacity and creativity as DV, and enjoyment as a mediator variable (MedV) together with self-perception to provide a comprehensive measure of the effect of IV on DV. Pre-Post changes for each intervention group (RI and NI) was used as DV. A dummy variable was computed to distinguish RI and NI intervention. Specifically, the dummy variable took the value 1 for data corresponding to RI and 0 for data corresponding to NI.

Additionally, a moderator analysis was employed to investigate the role of BMI and age (as ModV) in influencing the effect of IV on DV. The total, direct, and indirect effects estimate was reported using β together with 95% Confidence Intervals (CI, lower: upper limits), while the significance level was set at $\alpha = 0.05$. The statistical analysis was performed using Jamovi (V. 1.6, R 4.0).

4.3.7. **Results**

All data met the normal distribution. All tests were found reliable (DMA Locomotor: ICC = 0.945; DMA Stability: ICC = 0.936; DMA Manipulative: ICC = 0.966; DMA total score: ICC = 0.974; Mira Stambak's test: ICC = 0.923). Table 16 shows descriptive statistics of each variable for RI And NI.

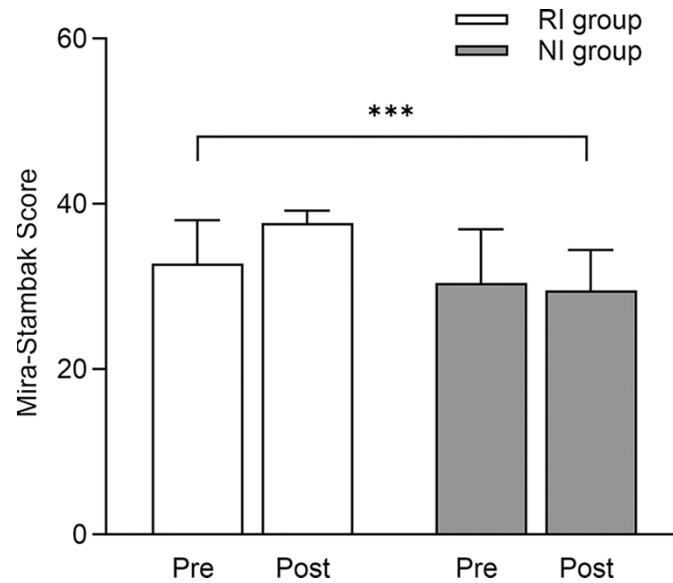
Table 16. Descriptive statistics for each intervention group (RI and NI).

		Variable	RI	NI
Pre	(au)	Locomotor (au)	41.9 + 7.2	41.7 + 5.3
		Stability (au)	31.8 + 6.5	30.7 + 5.2
		Manipulative (au)	36.4 + 8.7	35.4 + 7
		DMA total score	110.1 + 19.8	107.8 + 13.6
		Mira Stambak (au)	32.8 + 5.2	30.4 + 6.5
		PACES (au)	69.2 + 10.7	70.7 + 9.8
		PMSC - 2 (au)	31.4 + 4.7	33.6 + 5
		PSES (au)	18.7 + 3.1	19.1 + 3.8
Post	(au)	Locomotor (au)	47.7 + 5.5	41.7 + 4.9
		Stability (au)	37.4 + 9.5	31.2 + 8.9
		Manipulative (au)	44.6 + 7.4	36.2 + 7.6
		DMA total score	128.7 + 18.2	109.1 + 13.8
		Mira Stambak (au)	37.7 + 1.5	29.5 + 4.9
		PACES (au)	75.4 + 4.9	65.2 + 8.3
		PMSC - 2 (au)	35.6 + 3.5	31.1 + 4.4
		PSES (au)	20.4 + 3.3	17.5 + 4.2

Data are mean $\pm$ SD; RI = Rhythm Intervention; NI = No-Rhythm Intervention; DMA = divergent movement ability test; PACES = physical activity enjoyment scale; PMSC = perceived movement skill competence scale; PSES = physical self-efficacy scale.

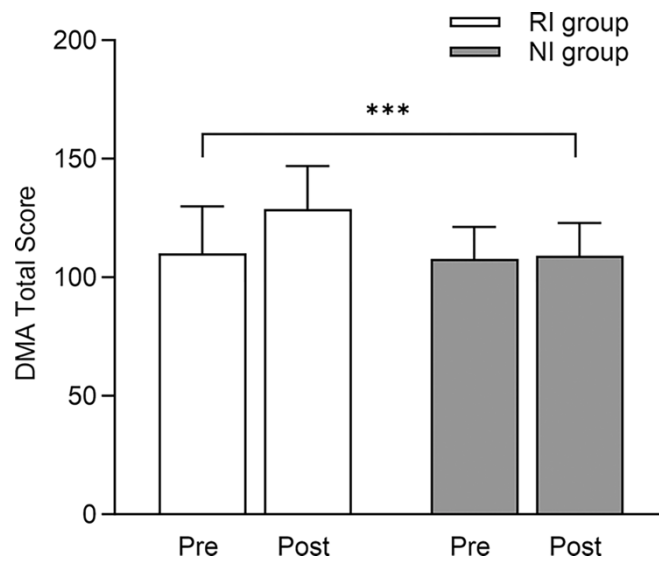
For rhythmic perceptive capacity, a significant Time $\times$ Intervention interaction was found ($p < 0.001$; $\eta^2 = 0.080$, medium). From Pre to Post, the RI group improved better than the NI group (Fig 14).

Figure 14. Effect of RI and NI on rhythmic perceptive capacity assessed by the Mira-Stambak Score. Data are mean $\pm$ SD. *** $p < 0.001$ for time $\times$ intervention interaction. RI = Rhythmic Intervention. NI = No-Rhythmic Intervention.



For creativity, a significant Time $\times$ Intervention interaction was found ($p = 0.001$; $\eta^2 = 0.041$, small). From Pre to Post, the RI group improved better than the NI group (Fig 15).

Figure 15. Effect of RI and NI on creativity assessed by the Divergent Movement Ability (DMA) Total Score. Data are mean $\pm$ SD. *** $p < 0.001$ for time $\times$ intervention interaction. RI = Rhythmic Intervention. NI = No-Rhythmic Intervention.

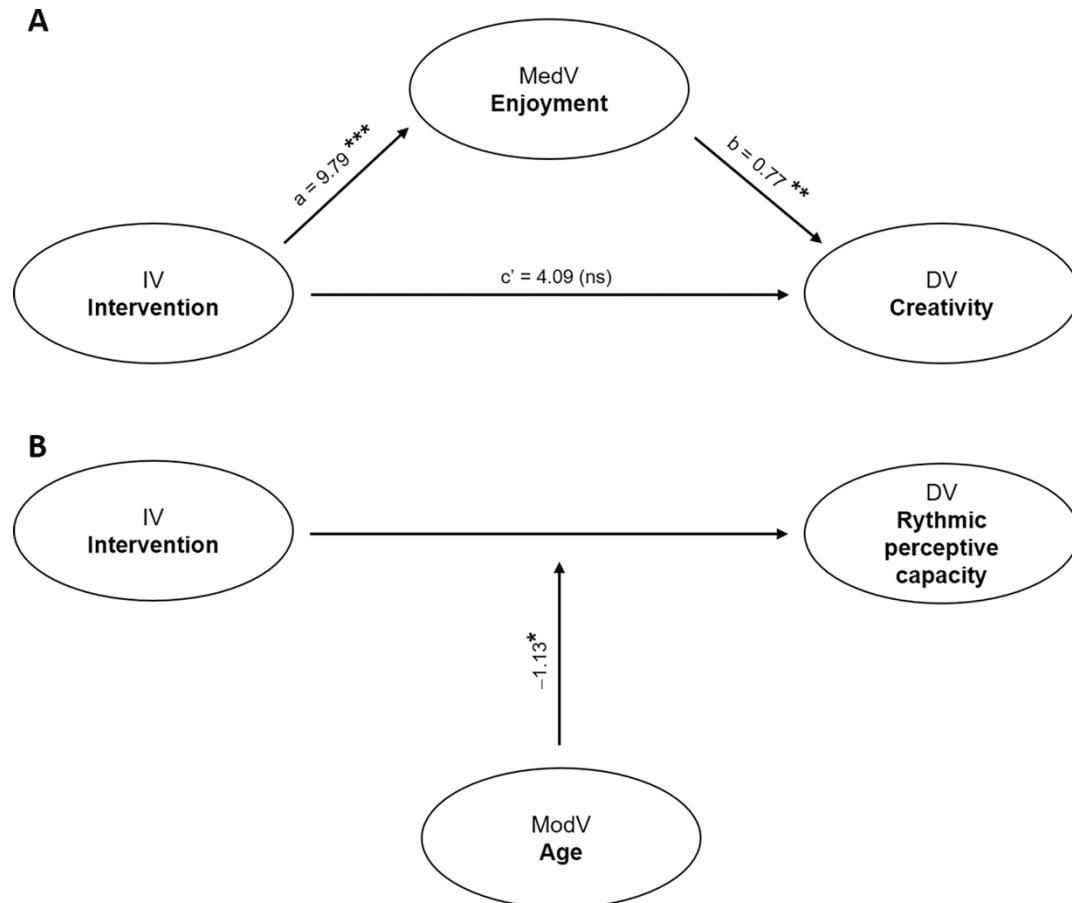


The first mediation analysis revealed that the intervention had a significant direct effect on rhythmic perceptive capacity ($\beta = 4.89$, $CI = 1.83:7.96$; $p = 0.002$). Conversely, no significant mediation by enjoyment was found (i.e., indirect effect; $\beta = 1.02$, $CI = -0.92:2.96$; $p = 0.30$).

Moreover, the second mediation analysis revealed that the intervention had no significant direct effect on creativity ($\beta = 4.09$, $CI = -4.83:13.0$; $p = 0.36$). However, enjoyment significantly mediated the effect of the intervention on creativity ($\beta = 7.63$, $CI = 1.76:13.5$; $p = 0.011$).

The third mediation analysis with self-perception variables showed that no significant mediation by PSES and PMC-2 was found (i.e., indirect effect; $\beta = -0.63$, $CI = -1.67:0.39$; $p = 0.22$; $\beta = -0.99$, $CI = -4.18:2.20$; $p = 0.54$) on the effect of the intervention on rhythmic perceptive capacity. Similarly, the fourth mediation analysis with self-perception variables showed that no significant mediation by PSES and PMC-2 was found (i.e., indirect effect; $\beta = 2.12$, $CI = -1.48:5.73$; $p = 0.24$; $\beta = 4.42$, $CI = -2.80:11.16$; $p = 0.23$) on the effect of the intervention on creativity. The moderation analysis revealed a significant moderating impact of age on the relationship between intervention and rhythmic perceptive capacity ($\beta = -1.13$, $CI = -2.16:-0.09$; $p = 0.032$), but not of BMI ($\beta = -0.62$, $CI = -1.54:0.30$; $p = 0.18$). Regarding creativity, the moderation analysis revealed a non-significant moderating impact neither of age ($\beta = -2.60$, $CI = -5.44:0.24$; $p = 0.07$) nor of BMI ($\beta = -1.41$, $CI = -4.13:1.30$; $p = 0.30$) on intervention – creativity relationship. Fig. 16 shows the structural model with the outcome of mediation and moderation analysis.

Figure 16. Panel A: Mediation model explaining the effect of intervention on creativity mediated by enjoyment. Panel B: Moderator model demonstrating age's impact on the effect of the intervention on rhythmic perceptive capacity. IV: independent variable; MedV: mediation variable; ModV: moderator variable; DV: dependent



Both SOFIT and IFITS evaluations resulted reliable (SOFIT – Intra-rater reliability: $R\% = 84\%$, Inter-rater reliability: $R\% = 82\%$; IFITS - Intra-rater reliability: $R\% = 80\%$, Inter-rater reliability: $R\% = 81\%$). The qualitative and quantitative analysis of teaching styles are shown in Table 17.

Table 17. SOFIT results for RI e NI groups and for grades

Group	Grades	Duration (min)	% MVPA	% MC	% PROM
RI	2 nd elementary school	57.5 ± 2.1	40.0 ± 0.2	47.7 ± 4.8	37.5 ± 3.7
NI	2 nd elementary school	59.0 ± 11.3	29.4 ± 11.5	53.7 ± 10.8	23.7 ± 19.5
RI	4 th elementary school	51.3 ± 2.4	62.3 ± 3.0	56.3 ± 3.7	32.7 ± 1.4
NI	4 th elementary school	47.2 ± 3.1	44.9 ± 0.6	54.3 ± 3.5	0.0 ± 0.0
RI	3 rd middle school	38.8 ± 4.5	62.8 ± 20.1	74.5 ± 18.1	38.6 ± 49.8
NI	3 rd middle school	37.0 ± 11.3	25.5 ± 3.6	65.6 ± 4.8	0.0 ± 0.0
RI mean		49.2 ± 8.9	55.0 ± 14.8	59.5 ± 14.9	25.7 ± 29.4
NI mean		47.7 ± 12.3	33.3 ± 10.6	57.9 ± 8.1	7.9 ± 15.0

RI = rhythmic intervention; NI = No-rhythmic intervention; MVPA = moderate to vigorous physical activity; MC = motor content; PROM = physical activity promotion

IFITS's results per group and grade are shown in Table 18.

Table 18. IFITS's results per group and grade.

Style	Duration	2 nd elementary school		4 th elementary school		3 rd middle school		Group mean	
(%)		RI	NI	RI	NI	RI	NI	RI	NI
Command		14.6 ± 10.7	4.6 ± 1.9	30.5 ± 8.4	23.5 ± 8.2	8.0 ± 0.7	10.4 ± 14.7	17.7 ± 12	12.8 ± 11.5
Practice		16.4 ± 23.2	0.0 ± 0.0	39.9 ± 2.2	31.0 ± 7.2	47.0 ± 9.6	28.4 ± 2.5	34.4 ± 18.2	19.8 ± 15.7
Reciprocal		10.5 ± 14.9	6.8 ± 2.2	0.9 ± 1.3	0.0 ± 0.0	6.5 ± 9.3	4.8 ± 6.7	6.0 ± 9.0	3.9 ± 4.5
Self-Check		0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	4.8 ± 6.7	0.0 ± 0.0	1.6 ± 3.9
Inclusion		0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Guided		0.0 ± 0.0	12.5 ± 17.7	19.8 ± 6.7	20.7 ± 2.4	10.7 ± 15.2	5.6 ± 7.9	10.2 ± 11.6	12.9 ± 11.1
Discovery									
Divergent		4.3 ± 6.1	15.8 ± 13.9	2.5 ± 3.6	0.0 ± 0.0	0.0 ± 0.0	2.4 ± 3.4	2.3 ± 3.7	6.0 ± 9.9
Go Beyond		0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Management		54.2 ± 8.6	60.3 ± 0.3	6.6 ± 1.3	24.8 ± 13	27.7 ± 14.1	43.8 ± 12.5	29.5 ± 22.6	43 ± 17.8

RI = Rhythm Intervention; NI = No-Rhythm Intervention.

4.3.8. Discussion

This study in teaching physical education investigated the effect of a rhythmic approach on motor creativity and rhythmic perceptive capacity. The protocol of this research was based on system thinking and rhythms methodology. Teaching-learning and enjoyment in physical education are the main system elements that have been hypothesized to interact closely to determine direct or mediated effects on motor creativity and rhythmic perceptive capacity.

The main findings of the present study were that rhythmic teaching in physical education improved the rhythmic perceptive capacity and motor creativity in young students, which could be beneficial for other school subjects (i.e., music) (Trecroci et al., 2023). Furthermore, such a teaching approach would increase the amount of moderate and vigorous physical activity during PE lessons in line with the recommendations and strategies for promoting motor practice established by the World Health Organization and other policy statements (Pangrazi & Beighle, 2019; Vazou et al., 2019).

The rhythmic approach let the RI group achieve more significant improvements in rhythmic perception than the NI group, which did not focus on this ability, as Mira Stambak's test results showed. The significant improvements in the RI group's rhythmic perception compared to the NI group may be attributed to the specific nature of the intervention (Bharathi et al., 2019).

Analyzing the results of the DMA, the RI group showed greater motor creativity than the NI group after the eight-week intervention, although the guided and divergent discovery styles were used more in the NI group. Our data appears to contradict existing literature (Bournelli et al., 2009), suggesting that a nonlinear approach is primarily conducive to developing motor creativity and creative thinking (Invernizzi et al., 2019; Invernizzi et al., 2022). Despite greater use of reproductive and linear styles, the rhythmic intervention has represented the leverage point in the context of system thinking through which it was possible to obtain substantial changes in motor creativity (Clarke et al., 2020; Trecroci et al., 2023).

Specific studies show how rhythm plays an important role in vital functions such as breathing and circulation and to guarantee coordinated actions in any movement (Gallahue & Donnelly, 2007).

Rhythm is the basis of all coordinated movement, and consequently, rhythm and movement can be efficiently combined to increase effectiveness in these interdependent domains (Phillips-Silver et al., 2010).

The rhythmic abilities of children and young people encompass creative experiences, including imitation and interpretation, such as folk and social dances, singing rhythms, auditory rhythmic mental representations, and motor skill guidance (Phillips-Silver & Keller, 2012).

By considering the relative importance of various factors in the context of system thinking, we hypothesized that utilizing an integrated multiple teaching style, which was indeed achieved in rhythmic physical education, could have led to a non-linear causal relationship with a more substantial outcome effect (Chow et al., 2021; Invernizzi et al., 2019).

Furthermore, greater use of practice and command styles in the RI group could allow learning better and consolidating rhythm and motor creativity skills. These observations are confirmed by the specific literature pointing out that internalization of a domain requires learning its rules and content through a large amount of information and frequency of stimuli obtainable through repeated exercises such as those guaranteed by practice and command styles (Thomson, 2009) (Table 18). Conversely, management was less employed in the RI group compared with the NI group in every grade. This may be due to the rhythmic approach and styles that require less organizational management than a productive approach (Mosston & Ashworth, 2008). Analysis of the quantitative aspects (Table 17) of the SOFIT data showed that although the duration and motor content were similar in both groups, the RI group performed more MVPA% (Moderate to Vigorous Physical Activity%). This confirms how even this quantitative factor stimulated by the rhythmic proposition, probably due to the fast-paced nature that a rhythmic approach may require, may have contributed to a higher chance of exercising and assimilating the domain (Vazou et al., 2019).

Furthermore, this data is not of secondary importance when also considering the effect of rhythmic teaching in increasing active practice (moderate and intense) during lessons with the consequent health benefits reported in the literature (Pangrazi & Beighle, 2019; Vazou et al., 2019; Wallhead & Buckworth, 2004).

The reciprocal style primarily used in the RI group allows a continuous relationship and feedback between students. Furthermore, the student acting as an observer learns to analyze and correct his partner's mistakes and stimulates critical thinking, which is essential in developing motor creativity. The interaction between the students determines the solicitation of social skills, making the proposals more exciting and pleasant (MIUR, 2012; Mosston & Ashworth, 2008).

The mediation analysis revealed that enjoyment was the only mediator that had a significant impact on the relationship between motor creativity and intervention. None of the other mediators under consideration had any impact on either the relationship between intervention and motor creativity or the relationship between intervention and rhythmic perception. The observed results can be primarily attributed to the direct impact of the rhythmic intervention, particularly when combined with a specific multi-teaching styles methodology (Invernizzi et al., 2019; MIUR, 2012; Phillips-Silver & Keller, 2012).

Durable sounds and sensations, such as those of the lullaby that mothers sing to children to make them fall asleep, determine sweet and pleasant rhythmic sensations, and reinforce the bond with their mother (Persico et al., 2017). This example illustrates how appropriate rhythmic activities in physical education, such as songs and simple dances, can create enjoyable and satisfying experiences, thereby stimulating the desire for learning and fun in children and young people (Pharez, 2016; Vazou et al., 2019).

Furthermore, listening to pleasant music integrated with movement helps stimulate divergent thinking, a key element of creativity (Ritter & Ferguson, 2017). However, it was impossible to consider this “music component” through the IFITS analysis because it was not contemplated as a possible type of divergent style.

By looking at the data from the perspective of the key concepts of system thinking, some effects could be delayed and made observable over a longer period (Jackson, 2016). This effect could occur when trying to change a complex system. Behavioral and interaction fluctuations (characterizing complex systems) may hide more possible connections between the variables and the mediators considered, making it take longer to see other possible effects (Jackson, 2016).

Although the literature recognizes possible relationships between positive self-perception, enjoyment, and competence not only in physical education but in

numerous fields of school learning (Monacis et al., 2022), we believe that the construction of a body image capable of mediating the relationship between rhythm and motor creativity, being the product of variables involving multiple domains in a transversal form, could require a longer intervention time to be assimilated determining a mediation effect (Şenol & Karaca, 2025; Sims, 1985).

The moderation analysis of intervention-rhythmic perception and age relationships shows a significant effect, highlighting how age and previous experience can affect rhythmic perception. Regarding motor creativity, weight appears to condition this domain. Students with a higher weight are generally older than those with a lower weight. Therefore, the age of practice could also condition motor creativity, and their expertise confirmed the relationship between age and DMA (Trecroci et al., 2023).

From the emerging results of this study, a multilevel model (Bronfenbrenner, 1979) based on system thinking can be characterized by three systems that, through a closed chain of causal connections, determine the effectiveness of the systemic approach. These three systems are:

- The exosystem, which is made up of the most distant level from the subjects towards whom the experimentation is directed. This system is represented by legislation, policies, and governance systems that, in a scholastic context, represent the national guidelines (ministerial guidelines) (MIUR, 2012) that, by the support of empirical and scientific evidence, have acknowledged the important role that rhythmic education, creativity and the transversal/transdisciplinary nature of the proposals, play in the education of children and young people;
- the mesosystem, which represents an intermediate level, constituted by the cultural institutional reality of the school, made up of families, school leaders, teaching subjects, and other stakeholders. The efficacy of this intermediate level is characterized by an environment that permits the implementation of transversal educational experiments, avoiding being excessively repressive and conservative of boundaries of each discipline;
- the endosystem, which is made up of the environment in closest contact with the school children, of related teaching domain (music and physical education school subject) and its related fields (positive relationship and interaction between teachers transversally involved) (Bronfenbrenner, 1979).

This way, particularly relevant, is the teachers who direct the students' interest, support them, and consider the students' abilities by creating the right balance between "challenging proposals and execution skills" to promote pleasure and interest and avoid frustration by proposing tasks that are inadequate for them.

The mediation analysis revealed that enjoyment did not mediate the effect of the intervention on rhythmic perceptive capacity, suggesting that other variables (not assessed in the present study, such as attention, focus, and cognitive engagement) may play a mediating role in the relationship between the intervention and rhythmic perceptive capacity. This finding agrees with Vazou and colleagues (Vazou et al., 2019).

Regarding creativity, the mediation analysis revealed that enjoyment significantly mediated the effect of the intervention on creativity. This suggests that the positive effect of the rhythm-based intervention on creativity was partially mediated by the enjoyment experienced by the students during the intervention. These findings are consistent with previous research highlighting the importance of enjoyment and its positive effect in promoting creativity (Friedman & Förster, 2002; Nabi & Biswas, 2023). The intervention's rhythmic activities and music-based elements may have elicited positive emotions and a sense of enjoyment, enhancing the students' creative thinking and expression. Overall, this emphasizes the teacher's role in conducting physical education programs (like rhythmic-based interventions) utilizing strategies promoting enjoyment (Williams & Berthelsen, 2019).

The moderation analysis showed that age had a significant moderating impact on the relationship between the intervention and rhythmic perceptive capacity, indicating that the effect of the intervention on rhythmic perceptive capacity varied depending on the age of the students. This finding suggests that younger students may benefit more from rhythm-based interventions to improve their rhythmic perceptive abilities. However, no significant moderating impact of BMI was found, indicating that BMI did not influence the effectiveness of the intervention on rhythmic perceptive capacity. These findings are consistent with a recent study showing age-related differences in rhythm perception (Trecroci et al., 2023). Younger students' developmental stage and cognitive abilities may make them more receptive to rhythm-based activities and interventions.

Regarding creativity, the moderation analysis revealed a non-significant moderating impact of age and BMI on the intervention-creativity relationship. This indicates that neither age nor BMI significantly moderated the intervention's and creativity's relationship. These findings suggest that the rhythm-based intervention positively affected creativity across different age groups and BMI categories. This aligns with research showing the universal benefits of music and movement interventions on creativity in diverse populations (Theocharidou et al., 2018).

4.3.8.1. Limitations of this study

There is a paucity of literature on the relationships between rhythmic-motor teaching, motor creativity, teaching styles, children's motor engagement during the lessons, enjoyment, and self-perception. It is therefore essential to recognize that the scholastic thinking system could represent the foundation of future studies to provide objective data on the effectiveness of the framework of the ecological model in physical education (Trecroci et al., 2023).

Data of our model include a small number of participants for a clear analysis that considers differences in age, gender, and other mediators and moderators considered self-perception or weight. In particular, as for self-perception, we used two types of questionnaires to measure self-efficacy and perceived motor competence (due to the lack of a single validated instrument capable of evaluating this component in children in the first elementary classes and the young in the last years of middle school), the small number further reduce the representativeness of the outcomes.

4.3.9. Conclusions

This study emphasizes the relationship between rhythms and motor creativity and the importance of enjoyment in engaging during these lessons' typology. The results of the present study, which also considered teaching styles and the type of motor practice, provide new insights for school teaching and support system thinking as a way to understand how all variables involved in the learning process can favor or hinder learning itself. Identifying, distinguishing, and

analyzing the relationship between what is taught and what is produced represents a reflective practice confirming the adherence of our study with the reference frameworks setting themselves to an obliquity (to consider organizational, methodological, and environmental factors), and making PE teaching even more helpful and cutting edge.

Practical applications

System thinking allowed us to highlight two fundamental points of rhythmic teaching (leverage and resistance points) to improve motor creativity. Thanks to the particularity of these domains, the transversality between physical education and rhythmic-musical education is a leverage point that can lead to effective results. A little skilled teacher and an unfavorable environmental reality could represent a resistance point. To avoid this, a competent teacher should have the ability to create, through a varied and engaging rhythmic multi-teaching approach, adequate relationships and enjoyment with the students to whom he relates (proposals adequate to the age and subjects' characteristics, suiting what they can and know to do). Without these conditions, the resistance points compromise the project's possibility. An environmental reality (educational managers, music teachers, parents, educational and ministerial programs) should be based, above all, on the possibility of encouraging overcoming the educational boundaries of the subjects involved in the project (possibility of blending physical education with other subjects).

4.4. RELATIONSHIP BETWEEN MULTI-TEACHING STYLES AND DIDACTICS EFFECTIVENESS ON RUGBY INSTRUCTORS AND MINIRUGBY PLAYERS

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4.4.1. Abstract

Background/Objectives: The concept of educational System Thinking shows the rugby educational system as a network of multiple interactive and interconnected elements. However, the frameworks presented in the literature for developing sports practice through an educational vision and multisport do not always have direct transferability to instructors' training courses. The study aims to evaluate the correlation between rugby instructors' methodological and didactical competencies and compare them with children's motor competence and psychological aspects. **Methods:** two hundred twenty children (9.6 ± 1.1 years) and 50 instructors (39.0 ± 13.6 years) were enrolled. Instructors' competencies were investigated during the internship through evaluation sheets, questionnaires, and video analysis. Children's motor competence and psychological aspects were investigated through motor tests, questionnaires, and video analysis. **Results:** the correlation between methodological competencies and didactical-communicative competencies showed a positive significance, especially regarding production styles. Motor competence and play skills in children showed poor results. The group of instructors with more methodological competencies showed a strong correlation between motor competence and psychological aspects (a greater number of teaching styles used). **Conclusions:** for successful teaching, knowledge of specific technical skills is not enough, and it is important to consider all the factors (in particular, the teaching-communicative and methodological skills) that contribute most to instructors' skills.

Keywords: Teaching styles; sport education; competent instructor; didactical success; instructor's empathy; system thinking.

4.4.2. Introduction

The concept of rugby's educational system can be defined as a complex dynamic system that includes, from a System Thinking perspective, multiple

interactive, inter-dependent, and interconnected elements (Corrêa et al., 2016; Rigon et al., 2024; Rosas, 2017). The dynamic concept, in particular, refers to a current behavior understood in terms of deviations from past behavior that, concerning current regulations (Parlamento Italiano, 2023), envisions a view of sport not only in performance terms but primarily in educational terms (Renshaw, 2009). From this perspective, verifying the learning trajectories that make the different skills of the instructors interact with the motor and psychological evolution of the children attending the minirugby courses allows us to clarify and define the values and meanings that the Italian rugby federation attributes to youth sports practice. This 'educational diagnoses' of the didactics' reality, based on the 'System Thinking', represents a contextual mode of analysis. It allows us to adopt targeted actions, to improve and possibly direct and modify, non-functional contextual behaviors that interact and can negatively affect the educational concept which must characterize children's rugby training (De Savigny & Adam, 2009).

This way, several frameworks have been concerned with identifying references based on solid pedagogical models for the development of a sports practice aimed not only at performance but also at sports education (Casey & Kirk, 2020; Metzler, 2017). In an educative vision of sports practice, these pedagogical models must also be applied also to children's sports instructors as they should extend the sports model to an educational vision that transcends the reductive design of specific interventions with exclusive and limited specialised competitive aims (Casey & Kirk, 2020; Hulteen et al., 2018; Metzler, 2017; Sgrò & Lipoma, 2019; Siedentop, 1976). The planning, design, and implementation of model-integrated sports education and initiation pathways (Balyi et al., 2013; Varghese et al., 2021), are characterized by primarily progressive and sequential stages for the education of the body and through the body. These models are intended to guide the development of programs to maintain a positive attitude to sport throughout life. More specifically, they envisage, at the youth level, the construction of physical-motor fundamentals (physical literacy) steps, which are based on a comprehensive multilateral, multi-sport approach (Kirk, 2005). This varied activity makes it possible to add up the training values of different practices while reducing the adverse effects that unilateral sports practice can have (Kirk, 2005), also thanks to the attainment of a wider variety of motor skills (Stodden et al., 2008). However, these models do not always find complete didactic transferability in children's

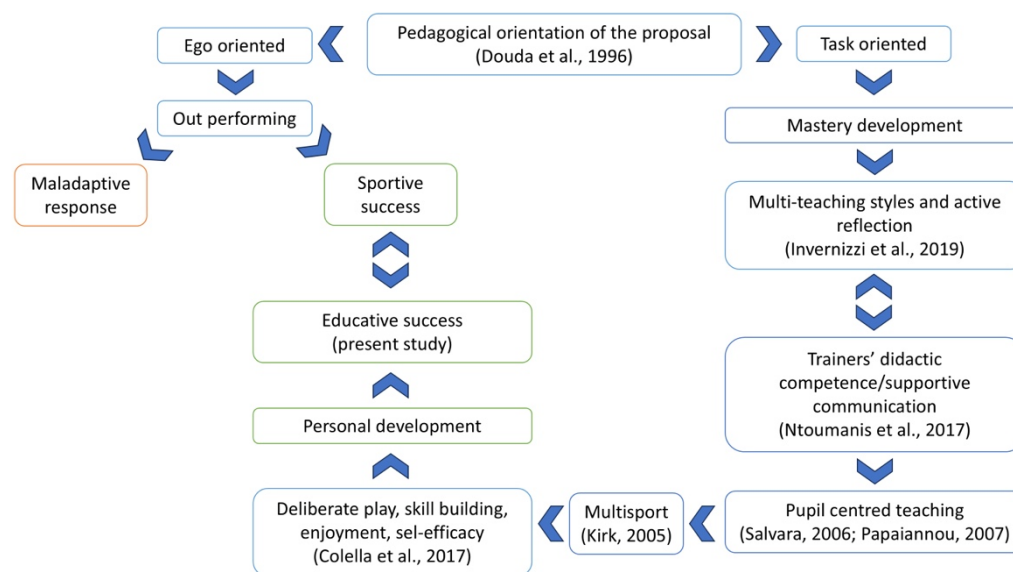
sports instructor courses, nor has their practical impact on young practitioners always been studied in terms of educational outcomes (Sgrò & Lipoma, 2019). Indeed, most federal sports training courses excessively focus on technical elements and performance (ego-oriented (Duda, 1996; Duda et al., 1995)) that can lead to feelings of inadequacy, excessive competition and rejection of the activity in their future young athletes, as evidenced by many authors and by an international systematic review (Manninen & Campbell, 2021; Malina, 2010; Myer et al., 2015).

In the Italian context, rugby instructors' training courses are proposed by formators of the rugby federation and are differentiated for technical competence of different ages (Level 1: Children, Level 2: Adolescents, Level 3: Adults) and competitive levels (categories of level 3: C, B, A, Excellence; categories of level 4: international rugby championship, national team). Future instructors can choose the formation course that better addresses their certification needs. Nevertheless, the courses attribute the qualification of instructor based primarily on “what to teach” and on knowledge and skills (sometimes only theoretical) to be acquired in planning, mastering, and often evaluating purely technical content (Gök & Aslan, 2023). This underscores the need for a more balanced approach in sports instructor's training focusing on “how to teach” (methodological competence based on teaching styles) and on instructors' empathic, emotional, and communication skills (didactical and personal competence based on management capacity and psychological constructs), which are indispensable for positively involving pupils (López-Pastor et al., 2013). In particular, a task orientation based on pupil-centered teaching styles seems to positively generate a motivational climate (Duda et al., 1995; Salvara et al., 2006). The teaching styles are all the various methodologies that teachers and children's sports instructors can use to efficiently and effectively achieve the set objective (Hewitt et al., 2016). They include various elements such as the teaching strategies used, the different modalities to propose specific experiences, the methods of communication with the children (for example, need-supportive communication), and the instructor's attitude towards the learners and teaching (instructors' personal competence; (Molina-Moreno et al., 2024; Ntoumanis, 2017)). Different teaching styles, especially in sports practice, allow to develop specific skills linked to the psychomotor, emotional, and self-awareness spheres (Patmanoglou et al., 2007; Rink, 2010). The continuous variation

and the wide use of a spectrum of possible teaching styles during sports practice (multi-teaching style approach (Invernizzi et al., 2019)) can help to better suit the sports didactics to the specific context and the children's needs. In a new and unconventional way, the multi-teaching style approach can be considered a non-linear (Chow et al., 2007) use of pedagogical-didactic methods as it can be continuously modified and adapted to context and situations, and it should be encouraged to solicit multiple and different aspects of children's identity. Moreover, using different teaching methodologies could also increase instructors' awareness of his/her educative effectiveness (Moy et al., 2019). Conversely, the prevalence of a single teaching style more frequently interpreted as direct, prescriptive, or command style can be considered as a linear and limited approach (Invernizzi, et al., 2019; Wang & Wang, 2014). The multi-teaching style primarily relies on intrinsic motivation and enjoyment in children. This methodological model encourages greater decision-making-oriented involvement of child learners by promoting new stimuli that facilitate the development of motor skills and psychological areas (Invernizzi et al., 2019).

In the teaching and sports education processes as well, the combination, variation, and interaction of teaching styles with reflective practices determine different ways of processing information and responses by learners, allowing for different, personalized learning modes (Hewitt et al., 2016; Invernizzi et al., 2019; Parker & Curtner-Smith, 2012). Hence, the sports instructor focuses on the teaching activity to carry out and, thus, on how to teach and why. The instructor's ability to use various teaching styles (methodological competence), didactics competence, and reflection can promote in the child an approach to sports practice that will lead to: reaching a healthy and active lifestyle; increase self-awareness and self-body scheme (self-efficacy); greater involvement in sports practice (enjoyment); maturation of new experiences and motor skills that can also be used in specific sports practice (motor competence) (Spittle & Byrne, 2009). Figure 17 summarizes the educational vision of sport that underlies this project.

Figure 17. A vision of the youth sports practice aimed at educational and sporting success (Colella et al., 2017; Duda et al., 1995; Duda et al., 1996; Invernizzi et al., 2019; Kirk, 2005; Ntoumanis et al., 2017; Patmanoglou et al., 2007; Salvara, 2006)



In a sport education based on rugby practice, fundamental educative values such as respect for teammates and opponents, collaboration between team members, and resilience while facing difficulties are promoted. These educative values contribute to sports education beyond technical competencies, considering social and emotional aspects essential for success (individual and collective) and for developing a solid and adaptable character (Muñiz et al., 2018). The teaching duality of sport and educative success in this discipline requires training to develop an adequate practice finalized on objectives that can focus on both dimensions (technical and socio-emotional). Hence, the instructors didactical/methodological capacities and the training sessions design, becomes essential when creating a specific environment to improve life and sports competence (Franks et al., 2001). Scientific literature considers approaches such as teaching games for understanding and tactical game approaches particularly suitable for this sport. Moreover, the child-centered approach (production teaching styles) is considered adequate for rugby's sports practice as it is based on a teaching-learning process

conceived on individual characteristics, needs and motivations (Thomas & Wilson, 2015; Browne et al., 2004). Nevertheless, to the best of our knowledge, no studies specifically addressed the teaching styles used by rugby instructors.

4.4.3. Aims

The present research analyzed rugby instructors' didactical (their communicative, organizational abilities and group management) and methodological competencies (the teaching styles they used) investigating the relationships between them. The relationship between motor coordination and psychological aspects (self-perception and enjoyment) in the children trained with and without a multi-teaching methodology by the instructors participating in this study was further analyzed. Finally, instructors' personal competencies, such as empathy and self-control, and their correlations with the psychological areas (enjoyment and self-efficacy) of children were investigated.

4.4.4. Materials and Methods

4.4.4.1. Sample

Before planning and offering a course for instructors of youth sport, researchers by the University of Milan wanted to explore the context of sports clubs where courses would be applied (which is the core of present research). Hence, 50 Italian rugby instructors from the youth sector of the local area (two Italian rugby clubs of the Lombardy region) and their respective trained children were recruited. The statistical power resulting from this instructor sample was 0.81. The statistical power was calculated with the G*Power pro-gram using an effect size estimate (Cohen's *d*) of 0.5. For this calculation, the student *t*-test for unpaired data was chosen. The same calculation was used to estimate the number of children required. 210 pupils allowed a statistical power of 95%; hence, a sample of 220 children was enrolled. Anthropometric data of children and instructors' samples are displayed in Table 19.

Table 19. Anthropometric data of the sample

	Children	Instructors
Sample size (n°)	220	50
Age (years)	9.6 ± 1.1	39.0 ± 13.6
Males (n°)	216	45
Females (n°)	4	5
Rugby teaching experience (years)		6.0 ± 5.7
Weight (Kg)	36.0 ± 7.5	
Height (m)	1.4 ± 0.1	
BMI (kg/m ²)	18.6 ± 3.3	

4.4.4.2. *Instructor's background*

The rugby instructors participating in the study were all certified by the Italian Rugby Federation (FIR) as “level 1 (children)” instructors. This certification allows instructors to train children from 5 (under 6) to 12 (under 12) years old. The 70% of recruited instructors had experience as rugby players, the 25% came from other sports, and the 5% had no sport experience. None of the participants came from a specific sport science university course.

4.4.4.3. *Protocol*

Instructors' behaviour (didactic competence) was defined by a list of descriptors used to promote motor tasks and the need for supportive communication. Didactics competencies were assessed during usual rugby training, at the beginning of the sport season, using a modified version of the "Internship Evaluation Sheet in Physical Education and Sports" (IESPES; Table 20; (Dewi & Kartowagiran, 2018; Hakim, 2015; Kirkpatrick & Kirkpatrick, 2006; Navickienė et al., 2019).

Table 20. IESPES Items' descriptors used and points assessment criteria.

Items	Descriptors ¹
Verbal communication	Comprehension; logic; choice of words of appreciation; choice of words of reproach; use of metaphors/narration. Assessment criteria: Adequate +1; Not Adequate 0
Voice and paralanguage	Volume; Timbre; Modulation; expository rhythm; use of silences and pauses. Assessment criteria: Adequate +1; Not Adequate 0
Non-verbal communication	Facial expression; eye gaze; eye contact; posture; proxemics gestures. Assessment criteria: Adequate +1; Not Adequate 0
Specific didactics	Choice of exercises; progression; demonstration; correction; adaptation of the proposal. Assessment criteria: Adequate +1; Not Adequate 0
Elements of organizational references	Location of tools; location in space of learners; safety/prevention/assistance rules; use of conceptual diagrams/charts/illustrations; time management (activity times; question times; organizational times). Evaluation criteria: Adequate +1; Not Adequate 0
Psychological references	Interest aroused; emulation level; expectations/requests; reinforcement; contextualization. Assessment criteria: Adequate +1; Not Adequate 0
Personal competence	Charisma; accuracy; confidence; empathy; self-monitoring Assessment criteria: Adequate +1; Not Adequate 0

¹Instructors were evaluated in each item of the schedule [32–35]. For each item the sum of score reached in all the five descriptors (0 or 1) compose the evaluation (from 0 to 5). The mean of all items' scores represents the final score.

Methodological competencies were investigated through the Teaching Styles Questionnaire (TSQ) (Goldberger & SueSee, 2020; SueSee et al., 2018), a self-reported questionnaire about the teaching styles used by the instructors.

IFITS and SOFITS systems were employed to verify the effectiveness of the use of different teaching styles by the instructors, the physical activity level of the children, and the interaction capacity of the instructor with them (Curtner-Smith, 2020; McKenzie et al., 1992).

Instructors' personal competence was investigated through the empathy scale for teachers (EST) (Wang et al., 2022), and the self-control questionnaire (SCQ) (Tangney et al., 2018).

In children, for the evaluation of motor competence, we utilized the Körperkoordinationstest für Kinder (KTK) to assess coordination skills (Kiphard & Schilling, 1974), and the Game Performance Assessment Instrument (GPAI) to assess game comprehension and sport-specific skills execution (Oslin et al., 1998). These practical and effective tools were complemented by three questionnaires to investigate self-perception (Colella et al., 2008), enjoyment (Carraro et al., 2008), and the type of physical activity performed (Crocker et al., 1997).

4.4.4.4. *Measures*

4.4.4.4.1. Instructor's Group

1. The Teaching Styles Questionnaire (TSQ) (Goldberger & SueSee, 2020; SueSee et al., 2018) is designed to examine teachers' teaching style methods and it has been used to evaluate sports instructors (Hewitt et al., 2016). The TSQ is based on the spectrum of teaching styles classified by Mosston and Ashworth (2008). The questionnaire presents each teaching style with a 5-point Likert scale. Points near to 5 express a frequent use of the teaching styles, while points near to 1 express an absence of use.

2. The internship evaluation sheet in physical education and sports (IESPES) (Dewi & Kartowagiran, 2018; Kirkpatrick & Kirkpatrick, 2006), the relationship between communication and education through the creative personality of the teacher, is a tool designed to evaluate the instructors' didactic competence. A score from zero to five points was attributed to communication capacity (verbal communication, voice, paralanguage, non-verbal communication),

didactics organization (specific didactics, elements of organizational references), and capacity of motivation and to engage the pupils (psychological references, personal competence).

3. The empathy scale for teachers (Wang et al., 2022) is a self-evaluation questionnaire developed to measure the empathy capacity of teachers during their lessons. The questionnaire is composed of 19 questions with a 4-point Likert scale. The questionnaire reports an empathy final total score and three sub-scores related to cognitive empathy, positive affective empathy, and negative affective empathy.

4. The self-control questionnaire (Tangney et al., 2018) is an evaluation tool for the measure of self-control. It is composed of items rated on a 5-point scale, starting from 1, "not at all like me", to 5, "very much like me". The questionnaire, composed of 36 items, reports a final self-control total score and eight subscale scores (impulse control, goal setting, distraction control, self-monitoring, task initiation, emotion regulation, automaticity, and decision-making).

5. video analysis IFITS (Curtner-Smith, 2020) and SOFIT (McKenzie et al., 1992). Two lessons were video recorded, and the IFITS and SOFIT analysis systems were used to verify the instructors' teaching styles, the children's levels of physical commitment during the lessons, and the interaction capacity of instructors with them. IFITS instrument gives the % of time spent on each instructor's teaching style. The SOFIT instrument gives the % of time spent in sedentary behaviours (lay, sit, stand) or moderate to vigorous physical activity (walk or vigorous activity), the % of time spent for each lesson content (skills, game, fitness, management, knowledge or other contents) and the % of time spent by the instructor in motivating children to activity (motivation focused on the inside lesson topic, outside lesson topic or not motivating).

4.4.4.4.2. Children's Group

6. Körperkoordinationstest für Kinder (KTK), (Kiphard & Schilling, 1974), is a coordinative test for children from 8 to 14 years old. It comprehends four tests (walking back, jumping sideways, moving sideways, and hopping for height). The result of each test is normalized, converted and summed into a total motor quotient score (MQ) using dedicated nomogram. The MQ indicates the children's level of body mastery that can be allocated into six ranges: disturbed (MQ = 50-

70), noticeable (MQ = 71-85), average (MQ = 86-115), good (MQ = 116-130), excellent (MQ = 131-145).

7. The Physical Activity Questionnaire for Older Children (PAQ-C; (Crocker et al., 1997)) was employed to determine the level of physical activity in the last seven days. Low scores (from 1 to 2.33) correspond to a low level of physical activity; medium scores are related to a moderate level (from 2.34 to 3.66) of physical activity, while high scores (from 3.67 to 5.00) imply a high level of physical activity.

8. The Game performance assessment instrument (GPAI; (Oslin et al., 1998)) is a validated tool that assesses children's ability to perform during sports games. The instrument evaluates the appropriate decisions or tactical executions, and the efficiency of skills performed during the game. Due to the high number of children, the present study focused the analysis only on the offensive phases and considered the scores performed by the overall team without analysing single players' outcomes. The game variables considered were decision-making, skill execution, support, and game performance.

9. The Physical Activity Enjoyment Scale (PACES; (Moore et al., 2009)) is a 16-item questionnaire that uses a 5-point Likert scale (1: completely disagree, 2: disagree, 3: uncertain, 4: agree, 5: fully agree). The questionnaire gives a final total score ranging from 16 to 80; higher values are related to higher enjoyment of the physical activity proposed.

10. A Physical self-efficacy scale for children (PSES; (Colella et al., 2008)) is a test that evaluates the self-perception of one's physical efficiency in motor skills, considered a primary motivational factor for voluntary participation in any physical activity and sport. It is composed of 6 questions and comprehends a 4-point Likert scale. The questionnaire gives a final total score ranging from 6 to 24; higher values are related to a more positive perception of the self.

This study was approved by the ethical committee of the University of Milan on the 13th of February 2024 with opinion number 14/24.

4.4.4.5. *Reliability of Internship Evaluation Sheet and video analysis*

To evaluate the intra- and inter-rater reliability of IESPES, SOFIT and IFITS, a video of 10 instructors' internships and the children's training (6 trainings) was recorded. Three different operators adequately trained to use the internship evaluation sheet analyzed the video. Every operator repeated the evaluation after two weeks. The video sequence was randomly assigned.

The GPAI intra- and inter-rater reliability process followed the same procedure but based on video of 2 different matches.

4.4.4.6. *Statistical Analysis*

The normal data distribution has been verified using the Shapiro-Wilk test.

The intra-rater and inter-rater reliability of IESPES was assessed using the Intraclass correlation coefficient (ICC). A reliability value above 0.70 was considered sufficient for the evaluation.

For the GPAI, IFITS, and SOFIT evaluation reliability, the following formula was used to assess the percentage of agreement between and within raters (Cleland, 1994; Van der Mars, 1989):

$$\% \text{ agreement} = \text{n}^\circ \text{ agreement} / (\text{n}^\circ \text{ agreement} + \text{n}^\circ \text{ disagreement}) * 100$$

An agreement rate of over 80% was deemed necessary for the test to be considered reliable.

The differences in IESPES, Self-reported teaching styles, IFITS, SOFIT, KTK, and GPAI results were investigated using the two-way ANOVA or the respective non-parametric Friedman test.

The Spearman correlation was performed to investigate the relationship between instructors' teaching styles and instructors' didactic competence (IESPES), the Spearman correlation was performed. Moreover, to assess relationships between instructors' characteristics and children's outcomes, two groups of instructors, a multi-teaching group (MG) and a no-multi-teaching group (NMG), were established considering the results of the self-reported questionnaire (TSQ). Instructors who used many teaching styles were enrolled in the MG, and those who used only one or two teaching styles were enrolled in the NMG. In this division,

we used the results of the teaching styles questionnaire and not the results of IFITS because the former concerned the entire experience of the instructor, while the latter referred to the observational analysis of only two lessons.

Spearman's correlation was applied to relate i) self-reported teaching styles and IESPES outcomes; ii) KTK normalized score and enjoyment in multi-teaching children; iii) KTK normalized score and enjoyment in non-multi-teaching children; iv) KTK normalized score and self-efficacy in multi-teaching children; v) KTK normalized score and self-efficacy in non-multi-teaching children.

Finally, to assess relationships between children's psychological aspects (enjoyment and self-efficacy) and instructor's personal competencies (empathy and self-control), no instructor group division was performed as we used questionnaires' results percentages. Hence, the correlations were assessed using the spearman's correlation.

For all mentioned analyses, the level of significance was set at 0.05.

A descriptive statistic was used for PACES, PSES, and PAQ-C general outcomes.

4.4.5. Results

4.4.5.1. Reliability results

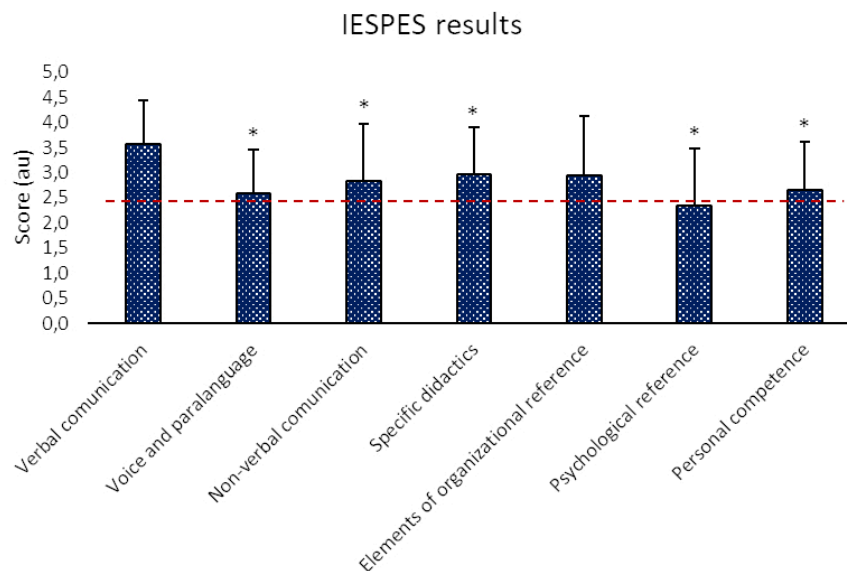
The IESPES obtained values of intra-rater ICC higher than 0.852 and inter-rater ICC higher than 0.886. GPAI, IFITS, and SOFIT evaluations obtained values of % of agreement higher than 82% for intra and inter-rater reliability.

4.4.5.2. *Instructors' descriptive results*

4.4.5.2.1. IESPES results

The ANOVA test revealed significant differences in IESPES results ($p < 0.001$, $\eta^2 = 0.13$). Post-hoc analysis revealed that verbal communication was the higher value obtained by rugby instructors ($p < 0.05$). Only the organizational elements item did not significantly differ from verbal communication in the post-hoc ($p = 0.09$). Results are displayed in Figure 18.

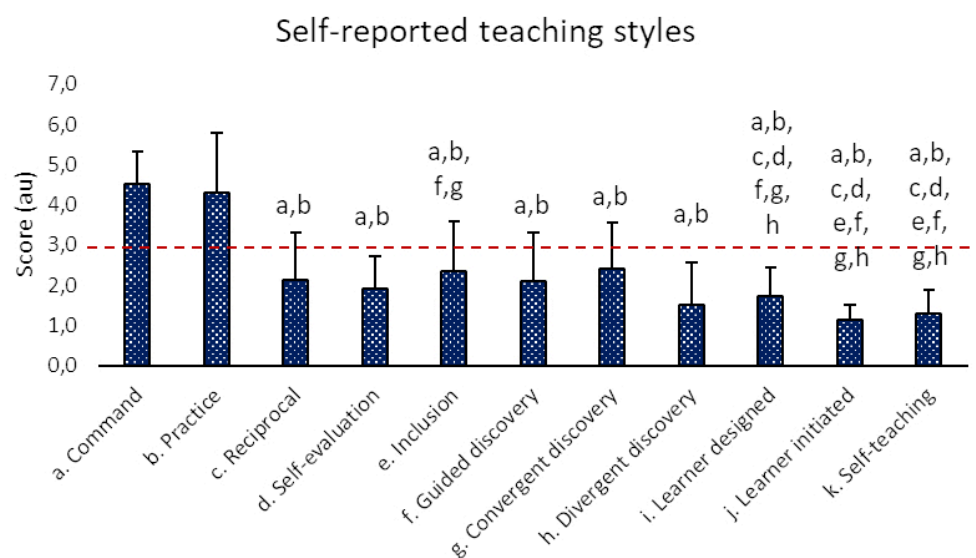
Figure 18. IESPES results. Red dashed line represents the minimum teaching competence score. Difference with "verbal communication": * = $p < 0.05$.



4.4.5.2.2. Self-reported teaching styles questionnaire's results

The Friedman test for the self-reported teaching styles resulted in significant ($p < 0.001$). Post-hoc revealed significantly higher values for the command and practice (a and b) teaching styles ($p < 0.05$) and lower values for all other teaching styles. All post-hoc analysis results are displayed in figure 19.

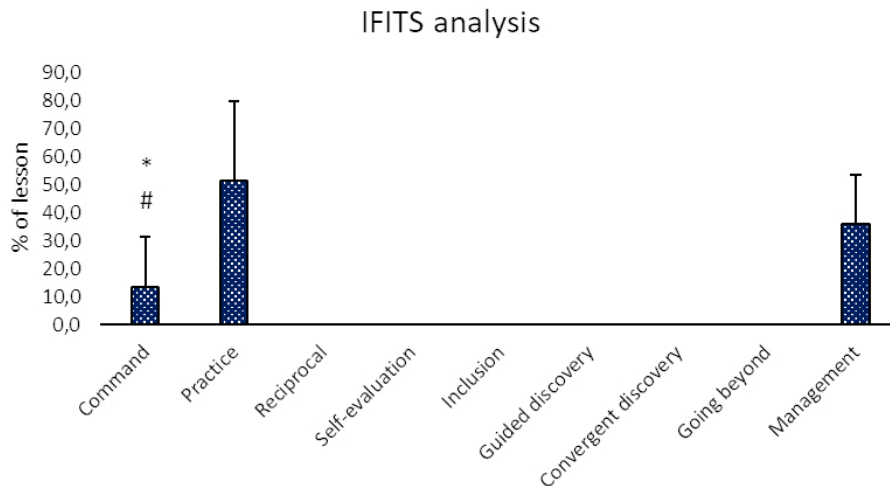
Figure 19. Results of self-reported teaching styles questionnaire. The red dashed line represents the value referred to as the “here and there” descriptor and was interpreted as the minimum arbitrary value (set at 60% of total score) to consider a teaching style sufficiently used during training. Letters indicate the significant difference with the



4.4.5.2.3. Teaching styles' video analysis results (IFITS)

The Friedman test resulted significant for IFITS analysis ($p < 0.001$). The post hoc analysis revealed that command style and practice are the only style used, confirming the prevalence of these methodology. Between the two, in the lessons analysed, the command style was the teaching style less used (13.2 ± 18.2 % of lesson, $p = 0.004$), while most of time was spent with the practice teaching style (51.1 ± 28.4 % of lesson) and management activities (35.7 ± 17.7 % of lesson). Results are displayed in Figure 20.

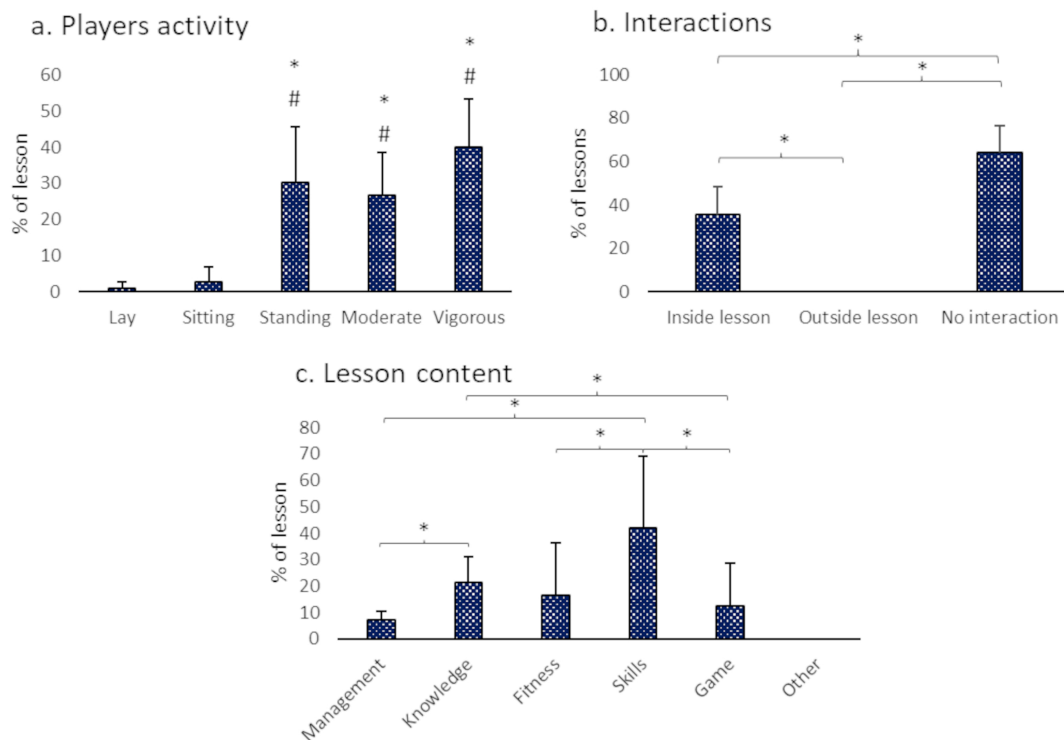
Figure 20. Results of IFITS analysis. Different than practice: * = $p < 0.05$. Different than management: # = $p < 0.05$.



4.4.5.2.4. Physical activity's video analysis results

Friedman's analysis of players' activity showed significant differences ($p < 0.001$). The post hoc analysis revealed that the main part of the lessons had been spent in standing (30.1 ± 15.4 % of the lesson), moderate (26.8 ± 11.6 % of the lesson), and vigorous (40.1 ± 13.2 % of the lesson) physical activity. Concerning instructors' interaction with children, the Friedman analysis showed that most instructors did not interact with children during lessons, few of them interact focusing on inside lesson topics, and no one of them interact focusing on outside lesson topics. Finally, the main content of rugby lessons was directed through the improving of specific rugby skills. Figure 21 shows all significant differences.

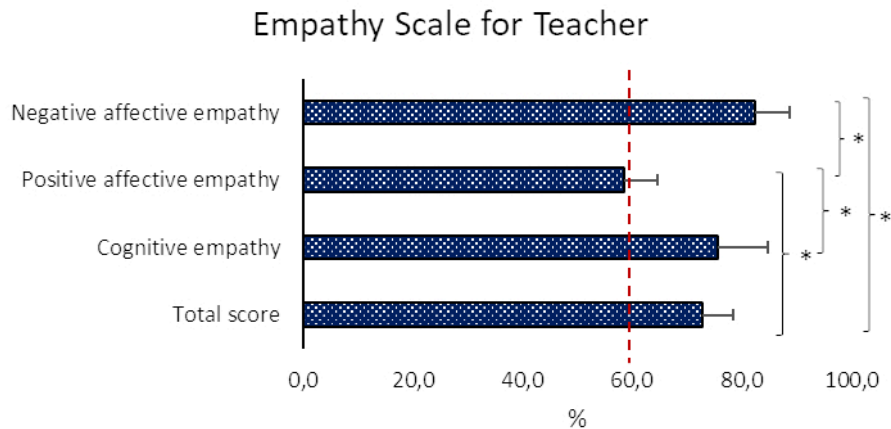
Figure 21. Results of SOFIT players activity (panel a), instructors' interactions (panel b) and lesson content (panel c). Panel a: Different than lay: * = $p < 0.05$; different than sitting: # = $p < 0.05$. Panel b: significant difference: * = $p < 0.05$. Panel c: significant difference: * = $p < 0.05$.



4.4.5.2.5. Empathy scale for teachers (EST) results

Regarding instructors' empathy, the positive affective empathy resulted was the lower value ($p < 0.05$) and the one lower than 60%, while the higher values reported were the negative affective empathy and the cognitive empathy. The results of the empathy scale for teachers are displayed in Figure 22.

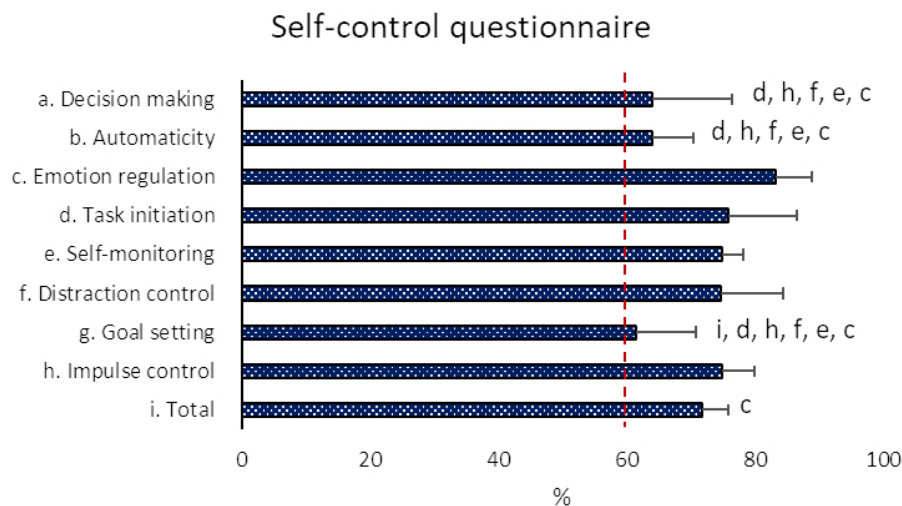
Figure 22. Instructors' empathy descriptive results. Red dashed line represents the cut-off line of low (<60%) or high (>60%) empathy. * = significant difference ($p < 0.05$).



4.4.5.2.6. Self-control scale results

The self-control questionnaire revealed that the instructors' sample had high values of emotion regulation, task initiation, self-monitoring, distraction, and impulse control. Conversely, the sample reported low values of decision-making, automaticity, and goal-setting (all close to 60% of the maximal reachable score). Statistical results of the Friedman's comparison are reported in Figure 23.

Figure 23. Instructors' self-control descriptive results. Red dashed line represents the cut-off line of low (<60%) or high (>60%) self-control. Letters indicate the significant difference with the respective self-control scale ($p < 0.05$).

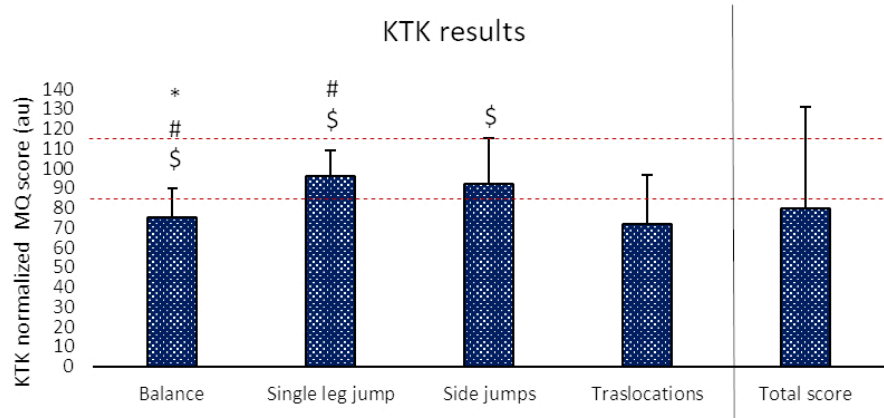


4.4.5.3. Children's descriptive results

4.4.5.3.1. Körperkoordinationstest für Kinder results (KTK)

The two-way ANOVA revealed a significant difference between KTK subtests ($p < 0.001$). The post-hoc analysis revealed that the higher scores were performed in single leg jump (96.3 ± 12.9 au) and side jumps (92.1 ± 23.1 au), which reached the normal score range (between 85 and 115 au). Other results are displayed in Figure 24.

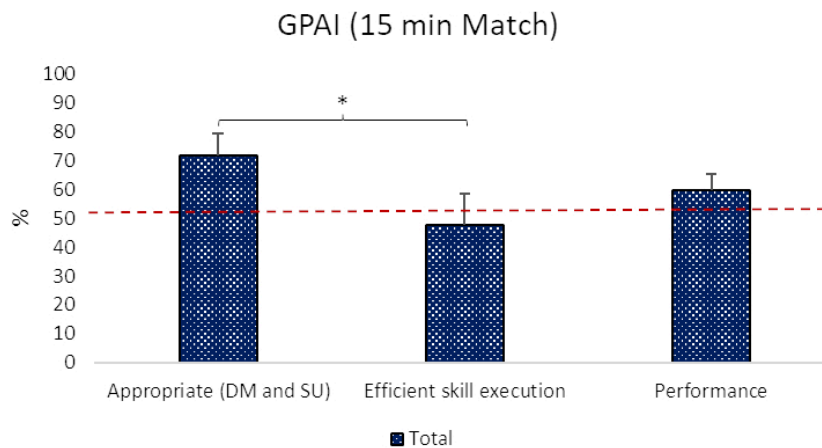
Figure 24. Results of KTK analysis. Significantly different than translocations: \$ = $p < 0.05$, significantly different than side jumps: # = $p < 0.05$, significantly different than single leg jump: * = $p < 0.05$. Red dashed lines represent the coordination normality range



4.4.5.3.2. Game Performance Assessment Instrument results (GPAI)

The Friedman analysis revealed that the children made higher percentages of appropriate decisions ($71.5 \pm 7.7\%$) compared with efficient skill execution, which resulted in low ($47.8 \pm 10.5\%$). No differences were detected with performance level ($59.7 \pm 5.8\%$). Results are displayed in Figure 25.

Figure 25. GPAI results. The red dashed line represents 50% of the total decision and execution performed. * = $p < 0.05$. Appropriate (DM and SU) = % of appropriate choices on the total choices (summing decision-making choices and teammate support) determined by the team; efficient skill execution = % of efficient skills execution on the total of the skills executed during the video recording; performance = % of success related to the efficient execution of the appropriate choice made by children (Memmert & Harvey, 2008).



4.4.5.3.3. Questionnaires descriptive results

Table 21 displays the results of the questionnaire and KTK reached by children and the % of maximal reachable point.

Table 21. Questionnaire results and % of maximal reachable point.

	Total scores ^a	Maximal reachable points	% of maximal reachable point ^a
PACES (au)	69.8 ± 6.6	80	87.3 ± 8.2
PSES (au)	17.0 ± 2.4	24	70.6 ± 9.9
PAQ-C (au)	2.7 ± 0.6	5	54.6 ± 12.0

^a Mean ± Standard deviation

4.4.5.4. *Correlation results*

4.4.5.4.1. Correlation between teaching styles and IESPES results

Correlation between teaching styles questionnaire results and IESPES results has been performed. For this analysis, the items “verbal communication”, “voice” and “non-verbal communication” were summed in the “communication” category. In the same way, “didactics” and “organizational elements” were summed in the “didactics” category, while “psychological elements” and “personal competence” were summed into the “motivation and personal competence” category. Moreover, teaching styles questionnaire results were summarized in “multi teaching” (number of teaching styles evaluated as 4 and 5, respectively “very often” and “most of the time”), reproduction (number of reproductive teaching styles evaluated as 4 or 5) and production (number of productive teaching styles evaluated as 4 or 5). Data were analyzed using Spearman’s correlation. Results are summarized in Table 22. Primary correlations are displayed in Figures 26, 27, and 28.

Table 22. Results of correlation analysis between teaching styles and IESPES results.

		Multi-teaching	Reproduction	Production	Communication	Didactics	MPC ¹	Total score
Multi-teaching	rho	1	-0.136	0.195	0.661**	0.486**	0.344*	0.323*
	p-value	.	0.346	0.174	<0.001	<0.001	0.014	0.022
Reproduction	rho	.	1	-0.072	0.400**	0.341*	0.137	0.335*
	p-value	.	.	0.618	0.004	0.015	0.342	0.017
Production	rho	.	.	1	0.564**	0.420**	0.283*	0.293*
	p-value	.	.	.	<0.001	0.002	0.046	0.039
Communication	rho	.	.	.	1	0.747**	0.479**	0.542**
	p-value	.	.	.	.	<0.001	<0.001	<.001
Didactics	rho	.	.	.	.	1	0.538**	0.792**
	p-value	.	.	.	.	.	<0.001	<0.001
MPC ¹	rho	.	.	.	.	.	1	-0.04
	p-value	.	.	.	.	.	.	0.782
Total score	rho	.	.	.	.	.	.	1
	p-value	.	.	.	.	.	.	.

¹MPC = Motivation and personal competence. * = p<0.05, ** = p <0.001.

Figure 26. Correlation graph between IESPES scores and the number of teaching styles prevalently used. IESPES scores: total score (panel a), didactics (panel b), communication (panel c), motivation and personal competence (panel d).

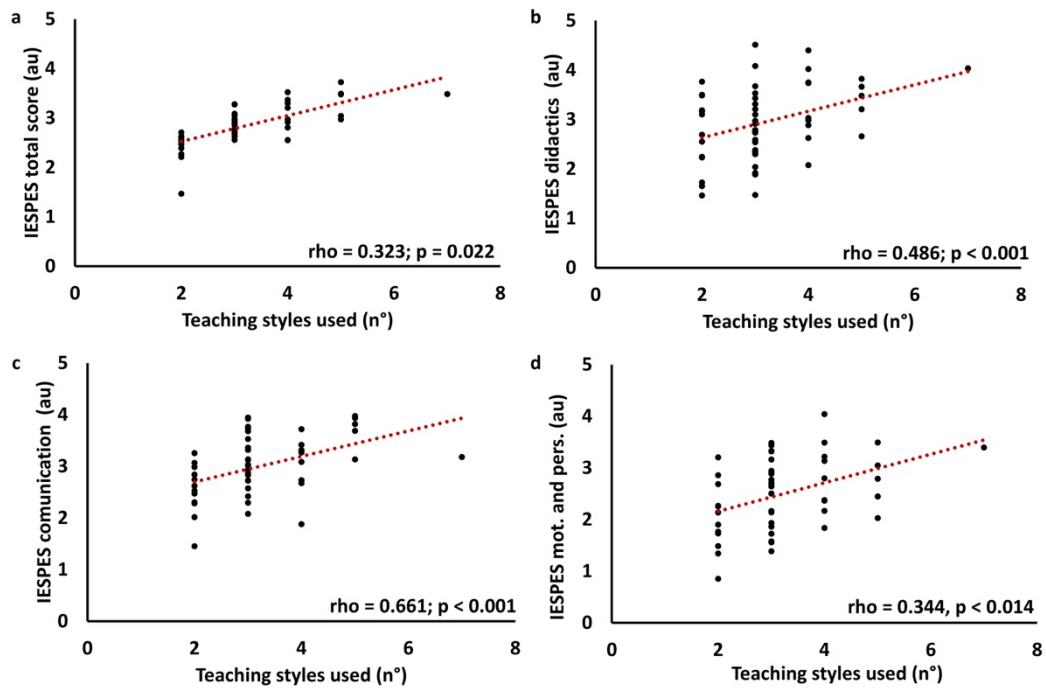


Figure 27. Correlation graph between IESPES scores and a number of reproductive teaching styles prevalently used. IESPES scores: total score (panel a), didactics (panel b), communication (panel c), motivation and personal competence (panel d).

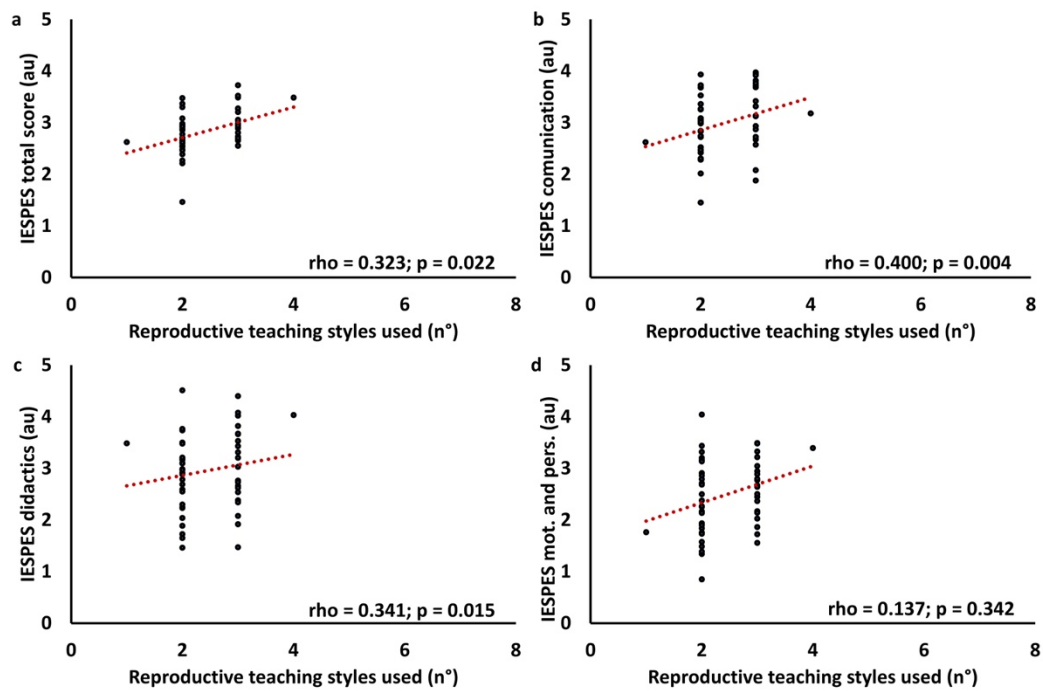
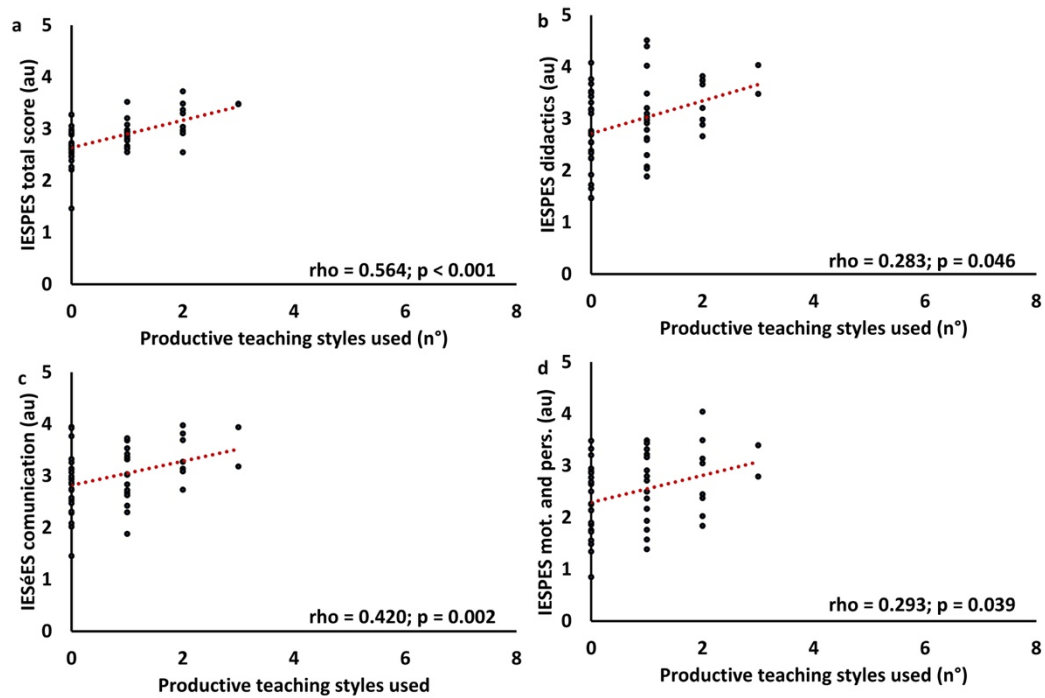


Figure 28. Correlation graph between IESPES scores and a number of productive teaching styles prevalently used. IESPES scores: total score (panel a), didactics (panel b), communication (panel c), motivation and personal competence (panel d).



4.4.5.4.2. Correlation results between motor competence, self-efficacy and enjoyment in children with multi-teaching and non-multi-teaching instructors.

Spearman's correlations were performed to evaluate the relationships between motor competence and psychological aspects in children with multi-teaching and non-multi-teaching trainers. Results are reported in Tables 23, 24, and in Figures 29, and 30.

Table 23. Correlation results between motor competence (KTK, PAQ-C), self-efficacy (PSES) and enjoyment (PACES) in children with multi-teaching trainers

Children with multi-teaching trainers		Normalized total MQ	PACES	PSES	PAQ-C
Normalized total MQ	rho	1	0,741**	0,727**	0,089
	p-value	.	<,001	<,001	0,383
PACES	rho	.	1	0,622**	0,167
	p-value	.	.	<,001	0,1
PSES	rho	.	.	1	0,102
	p-value	.	.	.	0,317
PAQ-C	rho	.	.	.	1
	p-value	.	.	.	.

* = $p < 0.05$, ** = $p < 0.001$.

Table 24. Correlation results between motor competence (KTK, PAQ-C), self-efficacy (PSES) and enjoyment (PACES) in children with non-multi-teaching trainers

Children with non-multi-teaching trainers		Normalized total MQ	PACES	PSES	PAQ-C
Normalized total MQ	rho	1	0,127	0,217*	0,16
	p-value	.	0,203	0,029	0,107
PACES	rho	.	1	-0,059	-0,011
	p-value	.	.	0,556	0,91
PSES	rho	.	.	1	0,393**
	p-value	.	.	.	<,001
PAQ-C	rho	.	.	.	1
	p-value	.	.	.	.

Figure 29. Correlation graphs between KTK and PACES (panel a), KTK and PSES (panel b), KTK and PAQ-C (panel c), PACES and PSES (panel d), PACES and PAQ-C (panel e), and PSES and PAQ-C (panel f). The sample considered is children with multi-teaching trainers

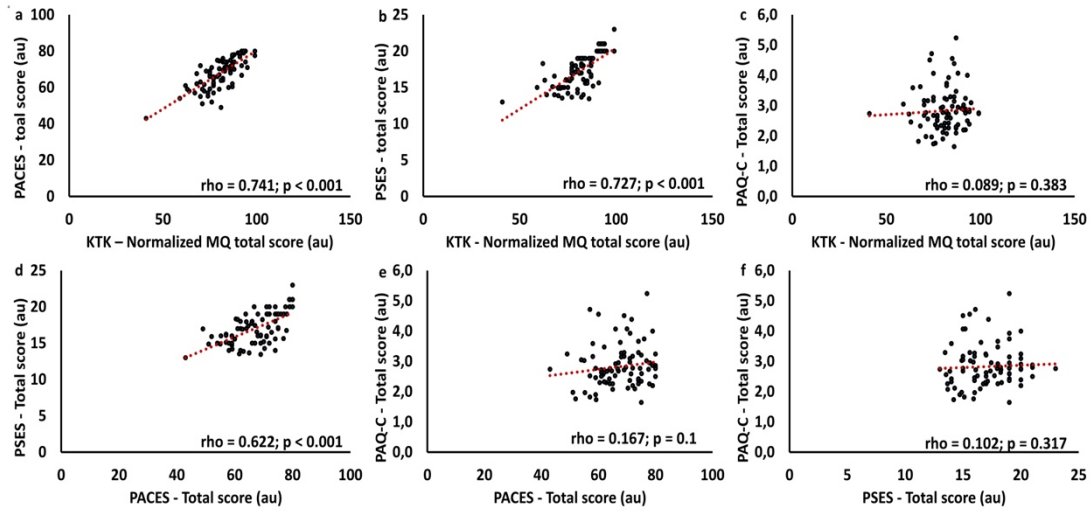
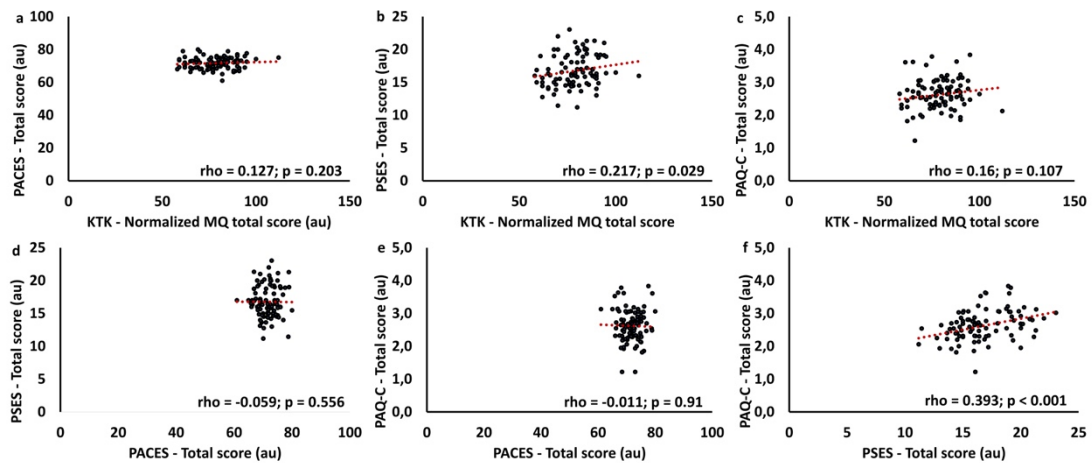


Figure 30. Correlation graphs between KTK and PACES (panel a), KTK and PSES (panel b), KTK and PAQ-C (panel c), PACES and PSES (panel d), PACES and PAQ-C (panel e), and PSES and PAQ-C (panel f). The sample considered is children with non-multi-teaching trainers.



4.4.5.4.3. Correlation analysis of enjoyment and self-efficacy with instructors' empathy and self-control

Spearman's correlations were performed to evaluate the relationships between children's psychological aspects (enjoyment and self-efficacy) with instructors' interpersonal competence (empathy and self-control). The main results are shown in table 25 and 26, while the complete correlation table are displayed in Annex 2 (Table a).

Table 25. Main results of enjoyment correlation table.

Table 25a			Empathy		
	Enjoyment	Total %	Cognitive empathy %	Positive affective empathy %	Negative affective empathy %
Enjoyment	1	0,281**	0,135	0,726**	0,019

Table 25b			Self-control						
	Total	IC	GS	DC	SM	TI	ER	AU	DM
Enjoyment	0,158*	-0,202**	0,296**	0,098	0,322**	-,298**	0,105	-0,255**	0,158*

Tables show rho values of the correlation of children's enjoyment vs instructor's empathy variables (7a) and children's enjoyment vs instructor's self-control (7b) variables. IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision making. * = $p < 0.05$, ** = $p < 0.01$.

Table 26. Main results of Self-Efficacy correlation table

Table 26a		Empathy			
	Enjoyment	Total %	Cognitive empathy %	Positive affective empathy %	Negative affective empathy %
Self-efficacy	1	0,397**	0,288**	0,288**	0,223**

Table 26b		Self-control							
	Total	IC	GS	DC	SM	TI	ER	AU	DM
Self-efficacy	-0,107	0,013	- 0,325**	-0,031	0,296**	0,035	-0,092	0,092	-0,324**

Tables show rho values of the correlation of children's self-efficacy vs instructor's empathy variables (8a) and children's self-efficacy vs instructor's self-control (8b) variables. IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision making. * = $p < 0.05$, ** = $p < 0.01$

4.4.6. Discussion

The present research aimed to evaluate the correlation between the rugby instructors' methodological competencies and their didactic competence. Moreover, this study aimed to evaluate and compare the effects of the variation in the teaching styles used on motor competence, self-perception, and enjoyment in children who received a multi-teaching style approach and children who did not.

From the results that emerged from this study, considering a mean score of 3 au (60% of maximal score), we can affirm that concerning didactics competencies, the instructors had good verbal communication skills, sufficient organizational skills, and specific didactics skills (exercises' choices, demonstrations, corrections, etc.). Nevertheless, they reported poor non-verbal communication (facial expressions, posture, gestures, proxemic gestures, etc.), personal competence (charisma, empathy, self-monitoring, etc.), skills in managing voice and paralinguages (volume, timbre, modulation, etc.) and psychological references (interest arouse, emulative level, reinforcements, etc.). Considering the statistical

analysis, the only describer that did not differ from verbal communication (reaching a sufficient level of expertise) was organizational skills. All the other describers indicated the need for intervention oriented to their improvement. The capacity to positively manipulate the different descriptors represents a key element in understanding how to help young people develop and maintain adequate physical literacy for sports and educational success (Stone et al., 1998).

According to a recent study, instructors revealed, through self-reported teaching styles, a prevalent use of the command and practice styles. In line with our results, Fernandez et al. (2021) reported that federal instructors use these styles more frequently; conversely, specialized PE teachers use a multi-teaching styles approach (Fernández & Espada, 2021).

Video analysis (IFITS analysis) showed that instructors exclusively used command and practice styles (mainly used). Furthermore, substantial time was needed to manage the activities, demonstrating poor employment of effective didactics. The instructors' poor time management capacity seems to contradict the IESPES organizational skills outcomes, nevertheless, the time management represents just one of the 5 descriptors that compose the evaluation. This should mean that even if rugby instructors are sufficiently able to spatially organize the lesson (considering location of tools, location of learners, safety/prevention/assistance rules, use of conceptual illustrations), they have difficulties in managing time during training. Children's sport sphere represents the most appropriate sample to experiment and check various learning approaches that could stimulate active participation and personal development. Nevertheless, the limited instructors' didactics and methodological skills represent a significant barrier to achieving these objectives (Leek et al., 2011).

Concerning physical activity involvement evaluated through the SOFIT system, time spent in moderate and vigorous physical activity (MVPA) is higher than sitting or lying, but considerable time is spent staying still. Deepening the analysis, the contents of the proposed activities are much more dedicated to skills learning than games and fitness, similar to cases highlighted by literature (Witt & Dangi, 2018). The instructor-children relationship during lessons is poor, and feedback is only related to the on-field practice. No instructor promotes the transferability of the practice of other activities or contexts necessary to promote a

multi-sportive education and a more comprehensive promotion of physical activity even outside sport-specific practice (Pesce et al., 2013).

The self-control questionnaire and the empathy scale for teachers which highlights higher levels of emotion regulation, and the low results of positive affective empathy can constitute two personal variables to be considered as elements to be improved to promote educational interaction with pupils (Meyers et al., 2019; Taxer & Gross, 2018).

Correlation analysis between Internship score (didactic competence) and the number of teaching styles used (methodological competence) showed a positive relationship between multi-teaching productive style and the total score reached in total didactic competence, organizational elements, specific didactics, motivation, and personal competence of the instructor. The correlations of the didactic competence with reproductive styles show the same results, except for the motivation/personal competence. These results agreed with Rivera-Pérez (2020), (Rivera-Pérez et al., 2020), who showed that multi-teaching motor tasks, both with reproduction styles (reciprocal, self-check following specific criteria) and production styles (divergent discovery for small groups), favor the development of soft skills emphasized with relationship dynamics (Rink, 2010; Rivera- Pérez, 2020), in children and adolescents. Communication skills are more related to positive correlations with didactics aspects, motivation/personal competence, and total score, confirming that didactics could be considered a communication science (Navickienė et al., 2019).

Considering the results of the analyzed children sample, the outcomes of motor competence in children present under motor normality levels, referring to the motor quotient of the KTK test. Similarly, game performance, determined by GPAI, evidenced results of less than 50% of effective skills executions despite the appropriate choices related to situational needs. The acquisition of adequate coordination could positively affect sport-specific skill learning. Indeed, skill competence could improve game comprehension, reducing failure after a good tactical choice depended on bad skill management (McPherson, 1994). Notably, El Khouri evaluated the effects of two learning units based on command and guided discovery styles on the gymnastics skills of two groups of children (El Khouri et al., 2020). Although learning results were similar in the two groups, the guided discovery styles guarantee better learning retention from the medium to long term

than the command styles. Furthermore, Da Silva showed how production styles, weakly used in our study by the rugby instructors, improved the learning of sport-oriented skills in team sports, such as decision-making, appropriate choice selection, and being active and involved in the games (Silva et al., 2020).

Preliminary results of the children's questionnaires evidenced high scores related to enjoyment and self-efficacy but insufficient general physical commitment of children concerning the total physical activity done. The correspondence between teaching and learning is determined by the choices and didactical decisions made, the questions the instructor formulates, and the expected responses (related to what task and how to execute). As previously highlighted in SOFIT, the poor interaction of the instructors in promoting further different sports and activities outside of rugby lessons may have influenced these results (Witt & Dangi, 2018; Pesce et al., 2012). Referring to the correlation between children's psycho-logical constructs (physical self-perception and enjoyment) and motor competence in MG and NMG, MG showed a strong correlation with motor competence, enjoyment, and physical self-efficacy, and NMG showed a weak correlation between competence and self-efficacy. Self-perception and enjoyment development are interdependent because they are the outcomes of motor tasks successfully executed and from their previous skills. How teaching styles vary and are interconnected is crucial for assessing the effects on motor learning and related psychological factors (Chatoupis & Emmanuel, 2003; Morgan et al., 2005). Motor competence is related to the type and variety of teaching styles used for positive living and its relationship with children's self-perception, which could sustain motor and sports practices (Colella et al., 2008; Carraro et al., 2008). This analysis suggests that research perspectives will have to proceed in different and complementary directions: on the one hand, the sports training of instructors through evidence-based didactics, and on the other, through analyses and studies geared towards enhancing not only motor performance (sporting success) but also the underlying psychological and social factors (educational success) (Duda et al., 1995; Duda, 1996). Rugby instructors' training courses must include significant experience in sports activity methodology and psycho-pedagogical sensitivity for children and young people.

Instructor's empathy and self-control are closely related to the children's positive psychological approach to the lessons (Meyers et al., 2019). More

specifically, in our study, empathy correlates with enjoyment and self-efficacy in children. These results are consistent with the literature, highlighting how this personal competence is an indispensable characteristic of an engaging instructor who does not demotivate children (Molina-Moreno et al., 2024). Regarding self-control, an instructor's excess of dirigisme and inhibitory behavior could negatively affect the children's intrinsic motivation and determine relational problems (Hagger & Chatzisarantis., 2007). In particular, an excessive definition of objective can lead to an excessive definition of executive rules with a greater possibility of children's failure and a lower sense of self-efficacy (Ryan & Deci, 2000). Similarly, the teacher with an excess of decision-making takes away decision-making autonomy from the children and, therefore, negatively influences their perception of self-efficacy. Regarding the relationship between self-control and enjoyment, an excess of impulse control and automaticity could reduce teacher creativity and spontaneity in lessons; an excess of task initiation could induce excessive pressure with a misunderstanding of the proposal and minor engagement (Cremin et al., 2009; Gorozidis et al., 2021; Tsai et al., 2018). A more frequent use of student-centered production styles and supportive communication could help solve these problems (Constantinides & Antoniadis, 2022; Ntoumanis et al., 2017; Salvara et al., 2006). This concept agrees with the principle of Self-determination theory and need-supportive communication. It highlights how autonomy and the discreet presence of the instructor, who must be present but let children experiment without doing it in his place, are critical elements of an effective sport and formative success with children (Ntoumanis et al., 2017). Finally, correlation results highlighted a direct relationship between both enjoyment and self-efficacy with self-monitoring (as part of self-control questionnaire). This means that a more reflective instructor who knows how to think about his/her behavior, proposal, and relationships during a training session can modify, implement, and improve the lesson for the pupils he/she is referring to when required. This way, the instructors' self-monitoring capacity could lead to a higher enjoyment of the sports practice and a higher sense of efficacy in children (Invernizzi et al., 2019; Kramer, 2018).

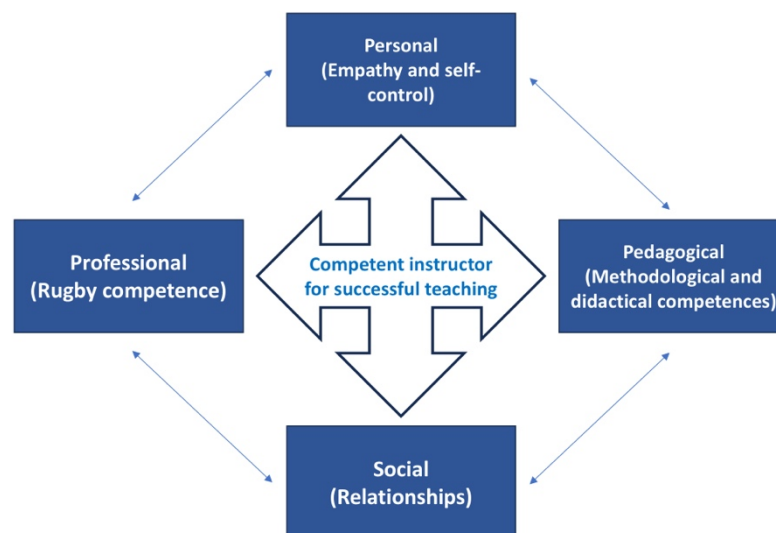
4.4.6.1. *Limitation of the study*

Two main limitations can be acknowledged in the present study. The geographical area of the rugby clubs from which participants were involved in the research was limited to the local area near the researchers' University in northern Italy. It could represent a relevant issue possibly affecting the generalizability of the results as sensible differences with other local areas surely exist with respect to facilities and/or rugby popularity and diffusion. Moreover, rugby is a sport prevalently practiced in Italy by male players and has few young female rugby players. For this reason, gender comparison has not been possible.

4.4.7. **Conclusions**

In a concept of rugby-oriented system thinking, our study well evidences the relationship between different instructors' learning skills and educational success (Figure 31).

Figure 31. Summary table of the relationship between the emerging learning skills of this study



The multi-teaching methodological approach and the connection with instructors' communicative teaching and empathic engagement skills positively influence the relationships between motor competence and the effects on children's psychological components. This interconnection highlights the importance of orienting instructor training on the ability to use varied teaching styles, especially production styles, which is a key leverage point for the educational success of their practice (Invernizzi et al, 2019).

A point of resistance that emerges from this analysis is the pupils' poor general motor competence, evidenced by the KTK, the GPAL, and the SOFIT observation of the instructors' poor interaction and involvement in promoting multilateral and multi-sportive motor practice in children, also carried out in the lessons (Pesce et al., 2012). Loop research between instructor/children variables to determine the effects of reciprocal interactions (circular loop based on "causal relationship chains" of direct and opposite return directions) supports a training approach based on instructors' methodological learning (Meadows, 2008).

4.4.7.1. Practical application

The present research established that training rugby instructors utilizing a multi-teaching reflective approach and implementing the children's interaction in promoting multi-sport activity outside lessons [14,29] could effectively contribute to creating the proper educational and methodological competence oriented to support both the sport and the educational success of young rugby players. In addition, empathic and self-monitoring capacities resulted related to children's psychological well-being, expanding the need for qualified instructors having technical skills to develop didactical and methodological competencies granting positive motor and psychological results. That can favor rugby performance and the development of a child's physical literacy.

4.4.7.2. Future research development

Studies and research need to be more frequently and systematically integrated into the settings where the teaching process occurs. In addition, studies on the teaching methods implemented in the different disciplines should be expanded and made more common to indirectly acquire knowledge on how

children learn sports-motor skills. Future studies should focus on the efficacy and transferability of instructors' courses based on a multi-sports and multi-teaching reflective approach to advance scientific evidence.

4.5. MULTISPORT-INTEGRATED TRAINING FOR RUGBY INSTRUCTORS: SUCCESS AND EFFECTS ON MINIRUGBY PLAYERS

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4.5.1. Abstract

Background/Objectives: The educational system thinking approach (ST) takes a holistic vision of instructors/teachers and learners' relationships, making sports pivotal for reflection on education. This study evaluated the efficacy of a multisport ST-based course on minirugby instructors' teaching competence and children players' motor conduct. **Methods:** The twenty-five rugby instructors (IAC) attended the 25 h course and the children of their teams ($n = 109$, Ch-IAC) participated in this study as experimental groups. Twenty-five rugby instructors who were not attending the course (I-CON) and their pupils ($n = 111$, Ch-CON) acted as control groups. Changes in instructors' teaching competence (by the Instrument for Identifying the Teaching Style and the System for Observing Fitness Instruction Time) and children's motor conduct (by the Körperkoordinationstest für Kinder test, the Game Performance Assessment Instrument, the Physical Activity Enjoyment Scale, and the physical self-efficacy scale for children) were assessed. **Results:** Thanks to the education received, IAC improved in didactics and methodological competence. They learned to use more production teaching styles than CON ($10.5 \pm 9.3\%$ vs. 0% of the lesson time, $p < 0.05$), reduce children's inactive lesson time for management ($-5.1 \pm 3.3\%$ vs. $1.1 \pm 3.1\%$, $p < 0.05$) and promote more outside lesson topics ($4.4 \pm 3.2\%$ vs. 0% , $p < 0.05$). In addition, compared to Ch-CON, Ch-IAC significantly improved motor coordination, game performance, enjoyment, and self-efficacy ($p < 0.05$). **Conclusions:** Children's enjoyment and self-efficacy acted as mediators that amplified the effects of the multisport training course. At the same time, the instructor's didactical and methodological competence were moderators directly favoring or worsening children's motor competence. Such an integrated multisport model is applicable and suggested for improving sports performance and education processes.

Keywords: teaching styles; teaching competence; system thinking; motor competence; sports education

4.5.2. Introduction

Sport can be assumed as a complex organism composed of a broader “systemic constellation” of parts that cannot be reductively approached by a narrow and independent analysis of the separate elements that compose it. In this complexity of inter-connections, the educational system thinking approach (ST) takes a holistic vision of the roles of instructors/teachers and learners in their own reality (Arango-Paternina et al., 2022).

The term educational system refers to a complex web of related elements interacting with each other and representing a coherent, unique entity of youth sports. Examples of integrated and interconnected elements leading to sport and education success are (i) the reference context and the training vision; (ii) the reference legislation; (iii) the administrative sphere; (iv) the technical, pedagogical, personal, and relational skills of the instructors; (v) the children’s motor and psycho-social skills.

In minirugby (the youth sector of rugby where children aged 5 to 12 learn the basics of rugby through simplified rules, reduced impacts, smaller field dimensions, and fewer players), the setting, the activities, and the social dynamics are key elements that can enhance the holistic approach based on the ST model. Each element can be structured over levels, from proximal to distal (Bronfenbrenner, 1977; Côté et al., 2007; 2020), such as follows:

- Setting: The methodological organization/structure of the minirugby program, the structure of the rugby club, and the broader structure of the community in which the club is embedded.
- Activities: Practicing the sport of interest, considering other physical/sports activities in different contexts, and engaging in complementary socio-cultural activities (school, art, music).
- Social dynamics: Within the specific sports context (instructor-child, child-child, and parent-child relationships), within complementary sports activities and group dynamics (interdependence, cohesion, identity), and within the socio-cultural sphere (external relationships with public and private entities).

A similar holistic approach was already applied in a previous study on minirugby to assess athletes and instructors’ skills, didactics and relationships (Rigon, Signorini, et al., 2024b). The ST approach must translate into positive outcomes

over time in the short (having the child fun and being engaged), medium (specific skills and connections acquired should be assessed), and long term (expecting success in sports, academics, and life), hopefully guaranteeing the child's complete personal development.

Therefore, academic educational research must be precisely oriented to the concrete needs of practice and the specifics of the contexts it addresses to be truly useful in addressing the complex problems of youth sports education. This is crucial for developing effective educational policies and practices in youth sports (Storey & Butler, 2013). The social reporting concept (Presidente della Repubblica, 1999) implies that intervention is sustainable and justified by tangible positive results, which, in sports, are generally accounted for through successful performances, but not limited to that since recently shifted towards the educational value of sport (Parlamento Italiano, 2023), which strengthened reflection on education's methods, objectives, and outcomes.

The broader educational role of sport is particularly facilitated by capable instructors who know how to stimulate the child towards varied motor experiences to capture their attention and interest in addition to the proposal of usual specific discipline skills. This way, teaching styles are recognized as fundamental methodological elements in an instructor's professional competence (Pill et al., 2023). Therefore, the training of sports instructors must include a strong focus on didactic-methodological skills, which are essential in educational processes and beneficial beyond sports and life in general. It is important to note that participation in a sporting activity alone does not always generate benefits (Coalter, 2015; 2017; Hartmann, 2003).

Effective educational communication is crucial: it supports people's successful involvement in sports and physical activity. In the athlete-coach relationship, communication is the key that unlocks the development of knowledge, understanding, and sharing of goals and beliefs, reassuring both parties and building a strong foundation for success (Sebire et al., 2013). One type of supportive communication is based on the Self-Determination Theory, founded on the three following needs necessary for educational success: (i) autonomy (i.e., the possibility to act as "actors" in one's actions); (ii) competence (i.e., feeling effective and confident in one's abilities, skills, and actions); (iii) relationship (i.e., feeling a sense of meaningful and reciprocal connection with others) (Ntoumanis et al., 2017).

Proper instructors' verbal and non-verbal language, voice and paralinguistic, specific organizational capacity, and psychological and personal competence represent the basics of effective and need supportive communication (Asún-Dieste et al., 2020; Jovanović & Zdravković, 2017; Ntoumanis et al., 2017).

Multisport practice, as a multi-teaching approach, and improvement in instructors' teaching skills (involving need-supportive communication skills) can represent a concrete operational translation, which, when applied, significantly enhances young people's motivation to participate in sports. Through this integrated approach, it is possible to manipulate information and instruction about the needs of young people, thereby helping them to develop and manage their motivation for sports participation (Kirk, 2005). Multisport practice allows children to learn to choose autonomously and to develop various proposals practical for creating elastic motor maps that can be translated into the ability to adapt/transform the motor competence to the required needs of different situations and contexts (Pesce et al., 2013).

An integrated approach, composed of multisport, multi-teaching, didactic, and organizational competence, makes it possible to orient teaching in a multi-purpose manner and target more towards the physical-motor, cognitive, or psycho-social areas, allowing flexibility of intervention adapted to the specific realities and educational needs of young people. The integrated approach plays a crucial role in managing educational interventions effectively. It ensures that teaching is targeted and efficient by minimizing downtime and periods of inactivity (Deci & Ryan, 2000; Fortier et al., 2012).

A scientific-based verification study of a methodological process of the training intervention is necessary to propose an integrated model that warrants complete didactic transferability in youth sport instructor courses (McKenney & Schunn, 2018). Specifically, the present model, based on that by Kirkpatrick and Kirkpatrick (Kirkpatrick & Kirkpatrick, 2006), is characterized by the following phases:

1. Theoretical reference training (in this case, model-integrated and multisport information).
2. Proactive workshop formula, focusing on sharing, deciding and formulating teaching objectives, discussing these with the learners and reflecting on didactic-methodological decisions.

3. Organization of traineeships (congruent with the knowledge of the theoretical topics covered) with proposals to be formulated by teachers for their colleagues and to children from different sports categories.
4. Analysis of the effects of the training proposal on teachers' teaching ability and of the transference that these effects present on the motor competence, enjoyment, perception of self-efficacy; amount of physical-motor commitment of the children attending the courses in which these instructors carry out their educational activities.
5. Evaluation of instructors' satisfaction with the training course.
6. Comparison of the effects of this training with those of youth sports instructors who follow the sports federations' standard, predominantly sport-specific and technical training.

This study aimed to evaluate and compare the effects of a multisport-integrated model training, oriented to emphasize the didactics and methodological competencies of the rugby instructors and, indirectly, on the effects (educational and sports success) of the training course on motor competence, game performance, self-perception and enjoyment in minirugby players. More specifically, this study investigated how a typology of integrated, multilateral, multi-purpose, and multisport training models for instructors can determine a direct transferability of results in terms of body education and education through the body in children attending specific sport introduction courses. We hypothesized that this training process significantly improves teachers' teaching ability and awareness about the effects of teaching by models-integrated/multisport methodology and the teaching styles they use. It is expected that the improvement of the didactic-methodological capacity translates into evident results on a psychomotor and psychological level in the training of the youth teams entrusted to the instructors benefiting from the specific multisport education compared to those who follow a traditional single-sport training mainly of technical nature.

4.5.3. Materials and Methods

4.5.3.1. Study Design

In this study, rugby instructors were recruited to evaluate the outcomes of the multisport-integrated training program, and the children belonging to each instructor's team were involved in estimating possible changes in motor and psycho-social competencies resulting from the instructors' training process. The sample size ($n = 45$) was previously calculated with the G*Power (ver. 3.1.9.2) program using a statistical power of 95% and an effect size estimate (Cohen's d) of 0.5. For this calculation, the student t -test for unpaired data was chosen. Since 25 rugby instructors joined the multisport-integrated training program, 25 FIR rugby instructors from another rugby club were required. The statistical power resulting from this instructor sample was 0.81. Therefore, a minimum of 210 total pupils was necessary to satisfy the previously set statistical power.

4.5.3.2. Participants

A total of 50 FIR rugby instructors from teams of the Milan area and 220 children of U10 and U12 categories (the children who played in the rugby instructors' team) participated in this study (Table 27). To be included in this study, instructors had to have an FIR training license and a minimum of two years of training experience but no bachelor's degrees in sports sciences. The instructors of the experimental group must have attended at least 75% of the training program lessons. Inclusion criteria for children were attendance at a rugby course and the absence of physical (e.g., muscle-skeletal) and cognitive pathologies (e.g., cognitive disabilities) that could alter the normal procedures of tests. They also attended not less than 75% of training sessions during the experimental period.

The instructors who participated in the training course and the children belonging to their respective teams composed the experimental groups (IAC = Instructors attending the course and Ch-IAC = children of the instructors attending the course); those who did not attend the training course and the respective children acted as control groups (I-CON, and Ch-CON, Instructors- and Children-Control, respectively). I-CON has not received further training in addition to that by federal specialistic rugby (i.e., the inclusion criterium).

Concerning children participating in this study, since women's rugby in Italy is a developing movement and girls usually approach this sport at a late age (after 12–14 years), the number of female minirugby players is minimal and does not represent a source of data bias. In addition, all children were at prepubertal age. Therefore, we decided not to exclude female players from this study.

Table 27. Participants' demographics and grouping specifics

Participants	Variable	Experimental (IAC, C -IAC)	Control (CON, Ch-CON)
Instructors	N	25 (21 m, 4 f)	25 (24 m, 1 f)
	Age (y)	36.2 ± 14.4	40.0 ± 12.8
	Teaching experience (y)	5.36 ± 6.0	7.0 ± 5.0
Children	N	109 (106 m, 3 f)	111 (110 m, 1 f)
	Age (y)	9.6 ± 1.1	9.6 ± 1.0
	Weight (kg)	36.5 ± 8.3	35.4 ± 6.5
	Height (m)	1.38 ± 0.07	1.39 ± 0.07
	BMI (kg/m ²)	19.1 ± 3.6	18.2 ± 2.8

4.5.3.3. Procedure

This study followed the randomized control trial model.

First, the baseline condition (pre) of instructors and children of the experimental and control groups was assessed. The instructors' initial levels of didactical and methodological competencies were determined: self-reported teaching styles and didactic interventions on their children's teams were collected, and the teaching approach while leading practice and the resulting amount of physical activity of their children were observed. In addition, motor competence, enjoyment, self-efficacy, physical activity, and play performance of the children belonging to the instructors' teams were also measured.

Over 6 months, the instructors of the experimental group (IAC) attended a multi-sport-integrated training and were allowed to immediately apply the newly acquired knowledge during the rugby training sessions with their respective teams (Ch-IAC). The instructors of the control group (I-CON) continued their usual training with the respective children's teams (Ch-CON). All the children were involved in a training period of 100 h per course distributed in 3 training sessions

of approximately six hours per week. Therefore, in Ch-IAC, one session per week was dedicated to multisport activities and two sessions to rugby-specific activities. All three sessions of the Ch-CON were only dedicated to rugby-specific activities. Measurements were repeated at the end of the multisport training course (post) to evaluate the outcomes on experimental instructors and respective children compared to controls, and further information about IAC satisfaction with the training attended was surveyed.

This study was approved by the ethical committee of the University of Milan.

4.5.3.4. *The Multisport Instructor Training Course for IAC*

The multisport instructor training course for IAC was structured as follows:

- Four meetings of 6 h and 15 min per meeting (25 h total—1 University Training Credit);
- A theoretical part in the classroom (2 h 15 min) structured with the following criterion: theory integrated with the subsequent practice of the internship (30/40 min); group work with discussions on the theoretical topics covered (15/20 min); questions from group work (a person in charge collects the requests for clarification that emerged from the previous discussion and addresses them to the trainers, 10 min); preparatory theory for the development of practical lessons (30/40 min); group work aimed at preparing internship interventions (themed lessons and methodological organization of the teaching moment, 15/20 min); questions from group work re-requesting further clarification on the internship (10 min);
- A practical part on the field, training with the coaches with an alternation in the roles of instructor, student, and observer (2 h);
- A practical part on the field, training with children with instructors who alternate in leading the lessons and observing (2 h).

The training process followed the main directions of the literature in its design (Harvey & Jarrett, 2014; Sgrò & Lipoma, 2019) and was characterized by:

- Proposal to rugby instructors with previous technical-sporting experience on which to base further knowledge and teaching-training strategies, in particular through multisport activities (basketball, ultimate, mini-volleyball, peteca, judo) valid for a specific transfer into the discipline;

- Sufficient duration of the experimentation (six months) and support to the instructors by the trainers, in the classroom and the field, to guarantee the learning and consolidation of the new skills;
- Composition of the team of trainers (scientific coordinator, teaching coordinator, researchers, doctoral students, and graduate students specially trained in administering questionnaires, motor tests, video recording, and analysis).

It was hypothesized that the model used to verify the effectiveness of the proposed educational teaching process satisfies the four key levels for the evaluation of teaching processes (Kirkpatrick & Kirkpatrick, 2006):

1. Satisfaction of the instructors with the program received, highlighting strengths and weaknesses;
2. Learning of knowledge, with greater awareness of the educational aspects of the multisport, of the teaching styles that can be used and their effects, of the languages that can be used in communication on the field and the gym through the acquisition of an expressive, empathetic and engaging them;
3. Modification of teaching behavior during internship experiences with coaches and children (ability to use different teaching styles and more effective educational communication; improvement of one's teaching-organizational skills);
4. Final results achieved (benefits acquired by the children who follow the multisport rugby introductory courses and determined by the educational training process followed by the instructors).

The multisport-integrated model of the training course and the timeline of procedures for experimental and control groups are shown in Figures 33 and 34.

Figure 33. Framework for the methodological process of the training intervention and the investigation using a scientific approach to verify the outcomes (Invernizzi et al., 2024)

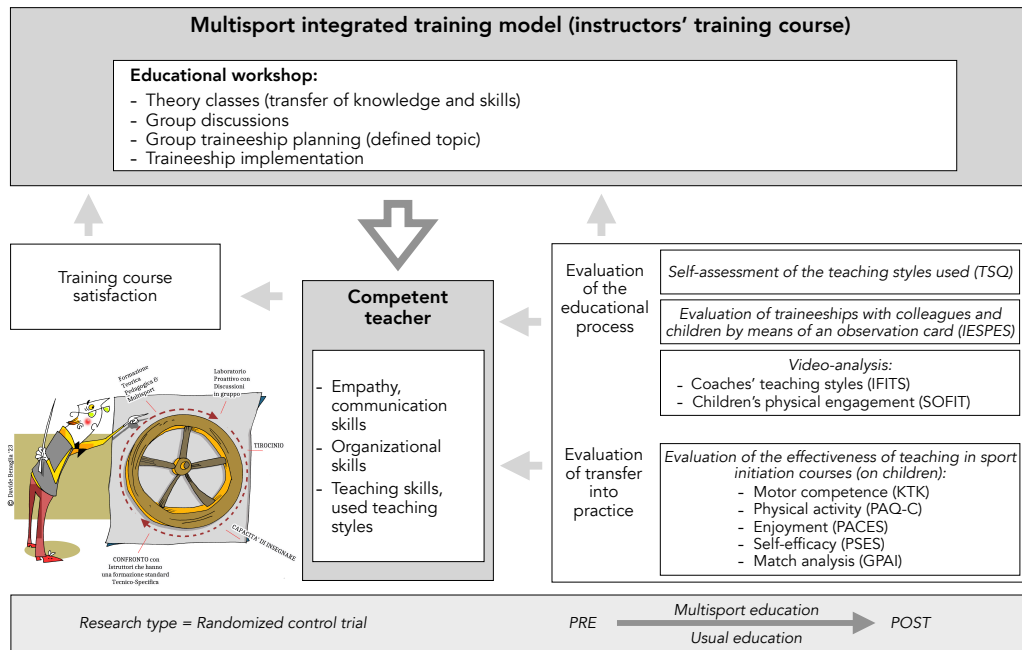
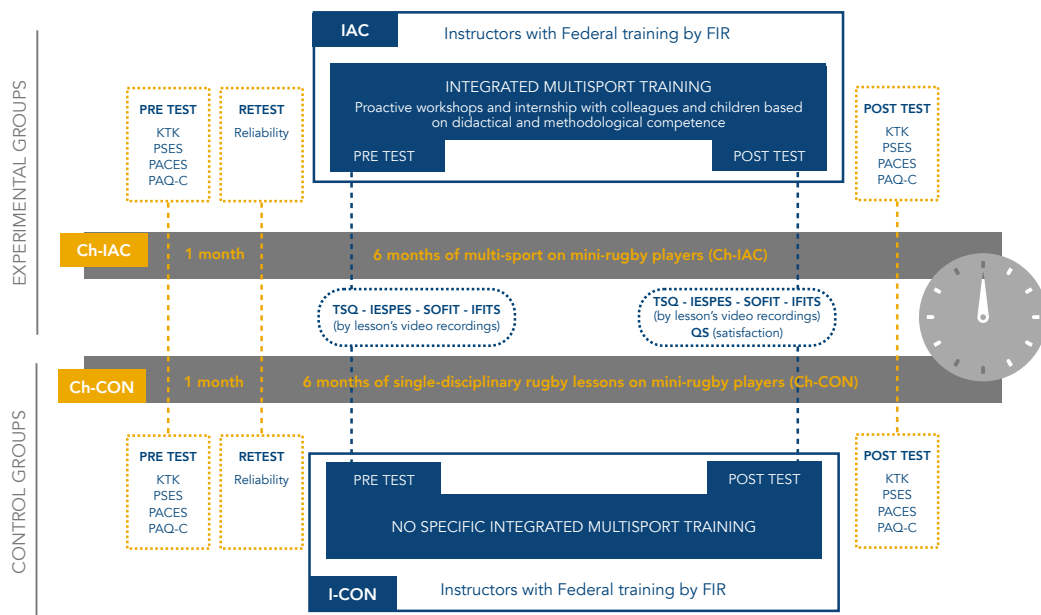


Figure 32. Timeline of the procedures followed by experimental (IAC and Ch-IAC) and control groups (I-CON and Ch-CON).



4.5.3.5. *Measures*

The instructors' methodological and didactic competence were assessed by the following instruments:

- Internship evaluation sheet in physical education and sports (IESPES) modified by Navickiene (Navickienė et al., 2019): It is a tool designed with the aim of measuring the different didactic competencies acquired during training with real practice in the field highlighted in the application context of the internship on children or colleagues involved in the training (Dewi & Kartowagiran, 2018; Kirkpatrick & Kirkpatrick, 2006). A score from one to five points is attributed to communication capacity, didactics organization, and capacity of motivation and to engage the pupils (Molina-Moreno et al., 2024). The descriptors of the modified IESPES are detailed in the Annex 3;
- The teaching styles questionnaire (TSQ) (Cothran et al., 2005; SueSee et al., 2018): It is designed to assess the instructors' perception of their teaching styles. It is composed of eleven items based on Mosston and Ashworth's spectrum of teaching styles scored by a 5-point Likert scale corresponding to the frequency of each style occurrence (Mosston & Ashworth, 2008);
- The questionnaire of satisfaction (QS) by Kirkpatrick and Kirkpatrick (Kirkpatrick & Kirkpatrick, 2006): It is a tool designed to measure the level of satisfaction of participants in the training course. The training program is considered satisfactory if the participating instructors are happy with it and motivated to learn. Participants' interest, attention and motivation to attend the course are indicators of the program's appreciation. The questionnaire is scored by a four-point Likert scale and includes thirteen questions. The questionnaire showed a good internal consistency equal to a Cronbach alpha value of 0.836.

Finally, some lessons were video recorded, and the Instrument for Identifying the Teaching Style (IFITS) (Curtner-Smith, 2020) and the System for Observing Fitness Instruction Time (SOFIT) (McKenzie et al., 1992) were used to verify the instructors' teaching styles and the corresponding children's levels of physical commitment during the lessons. Two lessons were recorded both before and after the intervention. The IFITS video analysis evaluates the percentage of time spent by

the instructors in each teaching style. The SOFIT video analysis evaluates the percentage of time spent by children in statical, moderate to vigorous physical activity. The content of the lessons and the type of the instructors' interaction were further analyzed.

To further check the success of the multi-teaching training program and possible outcomes differentiating instructors attending the course from those acting as a control, some parameters of children composing the teams led by the instructors were analyzed. Specifically, children's level of coordination, amount of physical activity, game performance enjoyment, and perception of motor competence were assessed by the following instruments:

- Körperkoordinationstest für Kinder (KTK) (Kiphard & Schilling, 1974) is a product test that measures coordination skills. The KTK consists of four items; a final score can be obtained for each test. The scores are added and converted with the reference nomograms by age and gender, returning a motor quotient indicating the level of body mastery possessed by the subject.
- The Physical Activity Questionnaire for Older Children (PAQ-C) (Crocker et al., 1997; Oslin et al., 1998) aims to determine the level of physical activity in the last 7 days, including sports, recreational activities, dancing, climbing, cycling, and unstructured activities. Low scores (from 1 to 2.33) correspond to a low level, medium scores indicate a moderate level (from 2.34 to 3.66), and high scores (from 3.67 to 5.00) imply a high level of physical activity;
- The game performance assessment instrument (GPAI) (Oslin et al., 1998) aims to evaluate game performance behaviors that demonstrate tactical understanding and the player's ability to solve tactical problems by selecting and applying appropriate skills. Our study used it as the overall game performance of the whole team. To the different variables of the game (decision making, skills execution, support, game performance), judgments of appropriate/inappropriate and efficient/inefficient responses were given using percentages of total responses. A score is attributed based on an overall division between the number of appropriate versus inappropriate responses, and a score over one indicates more positive than non-positive responses. The GPAI video analyses were performed before and after the intervention.

- The Physical Activity Enjoyment Scale (PACES) (Moore et al., 2009) is a 16-item questionnaire validated for elementary school students from 12 to 16 years old. PACES scores the items answers based on a 5-point Likert scale (1: completely disagree, 2: disagree, 3: uncertain, 4: agree, 5: fully agree);
- The physical self-efficacy scale for children (PSES) (Colella et al., 2008) evaluates one's self-perception of one's physical efficiency in motor skills. This is considered a primary motivation for voluntary physical activity and sports participation. The test is scored 1- 24. The higher the score, the higher the self-efficacy.

A team of Sports Science experts and doctoral students conducted all measurements during the mini-rugby course practice. The entire data collection and intervention took place over eight months. Test reliability and intra/inter-operator reliabilities were performed to ensure the validity of the analysis.

4.5.3.6. *Statistical Analysis*

The normality of data distribution was verified using the Shapiro–Wilk test.

The Anova 2×2 (time $\times$ group) analysis was conducted with the aim of investigating the intervention's efficacy for IESPES, KTK, and PACES. This involved examining the time effect (pre vs. post), the group effect (experimental vs. control), and the interaction (time $\times$ group) for each analysis. The intervention's efficacy for self-reported teaching styles, IFITS, SOFIT, and PSES, was investigated using delta values (post–pre) and the Mann–Whitney U test (a non-parametric version of the unpaired t-test) due to the violation of the normal distribution of data. For all mentioned analyses, the level of significance was set at 0.05.

As the GPAI protocol required the analysis of only four matches (two pre- and two post-intervention), the GPAI data were analyzed using a percentage comparison. In addition, a multiple regression analysis was performed to obtain information about mediators and moderators. The mediation analysis was performed following Baron and Kenny's method and was aimed at establishing mediation criteria. We considered the intervention (multisport training course) as the independent variable (IV), the main outcome (the motor competence Δ MQ norm, i.e., the delta of normalized motor quotient) as the dependent variable (DV), and the mediators (enjoyment, self-efficacy, and PAQ-C) as the variables controlling the IV-DV

relationships. The mediation analysis was performed to evaluate a comprehensive measure of the effect of IV on DV and pre-post changes in the intervention group. A dummy variable was computed to differentiate the two intervention groups: 1 for the experimental group and 0 for the control group. Finally, the moderation analysis was performed to evaluate the role of a multi-teaching approach and the didactics competence of the instructors (as ModV) on children's motor competence (DV) and if they influenced the multisport training course (IV). A dummy variable of 1 was assigned for the experimental group and 0 for the control group. Concerning instructors' competence, a value of +1 was attributed to instructors' higher competence, 0 to instructors' average competence, and -1 for instructors' poor competence.

4.5.4. Results

Data describing the didactic approach of the instructors during teaching as surveyed by the IESPES (Table 28) revealed significant interactions in communication ($F = 15.837$, $p < 0.001$, $\eta^2 = 0.142$), didactics organization ($F = 4.63$, $p < 0.001$, $\eta^2 = 0.046$), motivation/personal competence ($F = 18.157$, $p < 0.001$, $\eta^2 = 0.159$), and the total score ($F = 33.896$, $p < 0.001$, $\eta^2 = 0.261$). Only IAC improved their scores in the post-intervention measurements.

Table 28. Instructors' didactic approach from the internship evaluation sheet in physical education and sports (IESPES) questionnaire.

IESPES Parameters	Time Point	IAC	I-CON
Communication	Pre	2.9 ± 0.7	3.1 ± 0.5
	Post	3.7 ± 0.4	3.0 ± 0.5
	Δ (post-pre)	0.8 ± 0.4 §	0.0 ± 0.3
Didactics organization	Pre	2.9 ± 0.7	3.0 ± 0.8
	Post	3.7 ± 0.7	3.2 ± 0.6
	Δ (post-pre)	0.8 ± 0.6 §	0.2 ± 0.5
Motivation and personal competence	Pre	2.4 ± 0.7	2.6 ± 0.7
	Post	3.6 ± 0.4	2.6 ± 0.7
	Δ (post-pre)	1.1 ± 0.6 §	0.1 ± 0.5
Total mean score	Pre	2.8 ± 0.5	2.9 ± 0.3
	Post	3.7 ± 0.3	3.0 ± 0.4
	Δ (post-pre)	0.9 ± 0.3 §	0.1 ± 0.2

Values (mean $\pm$ SD) are expressed in AU (score). IAC = instructors attending the training course; I-CON = control. Significant values: § = time $\times$ group interaction ($p < 0.05$).

The analysis of the instructors' self-reported teaching styles surveyed by the TSQ (Table 29) showed that before the training course, IAC reported having performed more multi-teaching ($p = 0.048$) and reproduction ($p = 0.016$) styles occurrences than I-CON during activity conduction. After the intervention, multi-teaching ($p < 0.001$), reproduction ($p < 0.001$), and production ($p < 0.001$) teaching styles of IAC were further different than I-CON. The deltas (post-pre) analysis between the number of reported style occurrences further showed that IAC improved their abilities and taught with a larger number of styles, differently than I-CON, who basically unchanged their teaching approach.

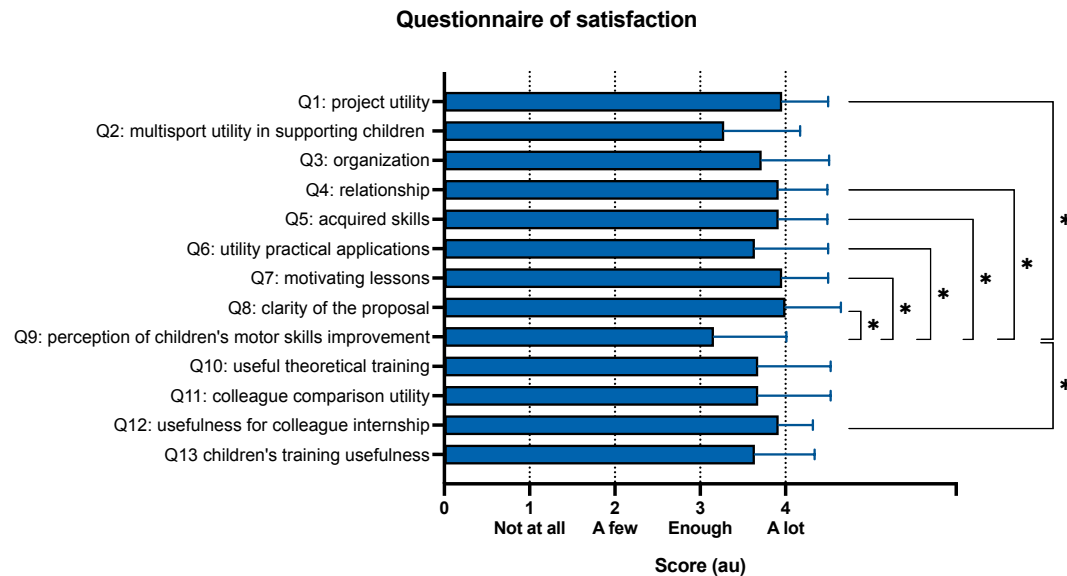
Table 29. Instructors' self-reported teaching styles from the teaching styles questionnaire (TSQ).

Teaching Style	Time Point	IAC	I-CON
Multi-teaching	Pre	$3.5 \pm 1.2^*$	2.9 ± 0.8
	Post	$4.8 \pm 1.3^*$	2.7 ± 0.8
	Δ (post-pre)	$1.3 \pm 0.9^*$	$-0.2 \pm 0.5 \Delta$
Reproduction	Pre	$2.6 \pm 0.6^*$	2.2 ± 0.5
	Post	$3.0 \pm 0.8^*$	2.2 ± 0.5
	Δ (post-pre)	$0.4 \pm 0.5^*$	0.0 ± 0.0
Production	Pre	0.9 ± 0.9	0.6 ± 0.8
	Post	$1.8 \pm 1.0^*$	0.4 ± 0.7
	Δ (post-pre)	$0.9 \pm 0.8^*$	-0.2 ± 0.5

Values (mean $\pm$ SD) are expressed in N (number of reported occurrences). IAC = instructors attending the training course; I-CON = control. Significant values: * = different than I-CON ($p < 0.05$).

In the QS questionnaire administered to IAC instructors to survey their satisfaction with participation in the multisport training course, question 9 (related to the perception of children's motor skills improvement), resulted in the lower. The Friedman analysis confirmed that the items of the questionnaire of satisfaction significantly scored differently ($p < 0.001$). However, the post hoc highlighted that only question 9 significantly differed from several other questions, as reported in Figure 34.

Figure 34. Results of the questionnaire of satisfaction (QS). In the survey, scores from 1 to 4 were assigned based on the level of satisfaction (1—not at all, 2—a few, 3—enough, 4—a lot). Significant difference: * = $p < 0.001$.



The instructors' self-reporting of the teaching styles surveyed by the TSQ was implemented by observing and analyzing some lessons by the IFITS (Table 30). The analysis showed a significant difference in pre-intervention practice teaching styles ($p = 0.038$), while in post-intervention, significant differences were detected in command ($p = 0.01$), practice ($p < 0.001$), inclusion ($p < 0.001$), guided discovery ($p = 0.010$), management ($p = 0.03$), and production ($p = 0.010$).

Table 30. Percentages of teaching styles used by the instructors as assessed by the Instrument for Identifying the Teaching Style (IFITS).

Teaching Style	Time Point	IAC	I-CON
Command	Pre	23.3 ± 21.9	4.9 ± 8.8
	Post	39.4 ± 13.6 *	8.8 ± 15.8
	Δ (post-pre)	16.0 ± 27.6	3.9 ± 13.2
Practice	Pre	37.6 ± 28.0 *	62.2 ± 24.6
	Post	20.0 ± 10.0 *	59.5 ± 21.2
	Δ (post-pre)	-17.0 ± 32.7	-2.7 ± 13.4
Reciprocal	Pre	N/U	N/U
	Post	3.5 ± 6.9	N/U
	Δ (post-pre)	3.5 ± 6.9	N/A
Self-check	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post-pre)	N/A	N/A
Inclusion	Pre	N/U	N/U
	Post	8.2 ± 1.8 *	N/U
	Δ (post-pre)	8.2 ± 1.8 *	N/A
Guided discovery	Pre	N/U	N/U
	Post	10.5 ± 9.3 *	N/U
	Δ (post-pre)	10.5 ± 9.3 *	N/A
Convergent discovery	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post-pre)	N/A	N/A
Going beyond	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post-pre)	N/A	N/A
Management	Pre	39.1 ± 11.3	32.9 ± 21.7
	Post	19.4 ± 10.4 *	31.7 ± 7.9
	Δ (post-pre)	-19.7 ± 17.3 *	-1.2 ± 17.3
Total Reproduction	Pre	60.9 ± 11.3	67.1 ± 21.7
	Post	70.9 ± 8.3	68.3 ± 7.9
	Δ (post-pre)	10.1 ± 15.7	1.2 ± 17.3
Total Production	Pre	N/U	N/U
	Post	10.5 ± 9.3 *	N/U
	Δ (post-pre)	10.5 ± 9.3 *	N/A

Values (mean ± SD) are expressed in percentage of the lesson total time (%). IAC = instructors attending the training course; I-CON = control. N/U = not used. N/A = not applicable. Significant values: * = different than I-CON ($p < 0.05$).

The physical commitment of the children depending on how the instructors conducted the lessons, as reported by the SOFIT analysis (Table 31), was similar in Ch-IAC and Ch-CON, confirming that there was no difference between IAC and I-CON conduction before IAC training. Conversely, after the training, IAC instructors improved their conduction: compared to I-CON, children belonging to IAC teams spent less time standing ($p = 0.043$), benefited from lessons having less

management ($p < 0.001$), reduced fitness ($p = 0.023$), and more game ($p = 0.017$) contents, and received more lessons outside topics ($p < 0.001$).

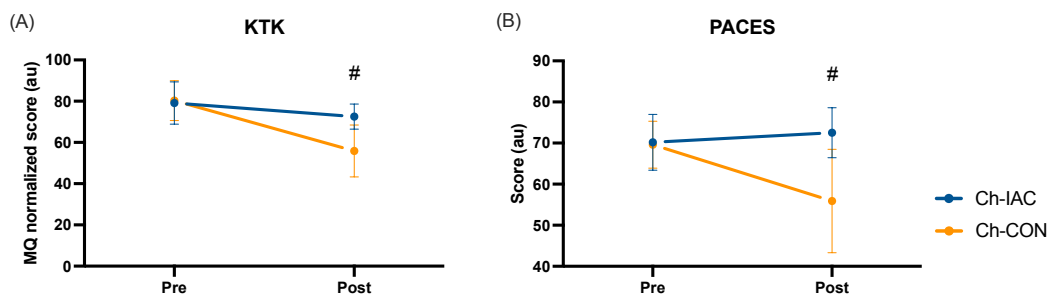
Table 31. Children's physical commitment during the lessons due to the instructors' conduction, as from the System for Observing Fitness Instruction Time (SOFIT) analysis.

Children's Commitment		Time Point	IAC	I-CON
Children's activity	Lay	Pre	1.2 ± 2.6	0.3 ± 0.9
		Post	0.9 ± 1.4	0.4 ± 0.8
		Δ (post-pre)	-0.3 ± 3.3	0.1 ± 1.3
	Seated	Pre	3.1 ± 4.6	2.5 ± 3.6
		Post	4.3 ± 3.3	3.7 ± 3.0
		Δ (post-pre)	1.2 ± 4.4	1.2 ± 4.5
	Stand	Pre	33.6 ± 16.3	26.6 ± 14.4
		Post	11.2 ± 5.6 *	20.2 ± 12.3
		Δ (post-pre)	-22.4 ± 20.4	-6.4 ± 22.9
	Moderate	Pre	25.1 ± 11.9	28.5 ± 11.6
		Post	34.8 ± 9.0	31.2 ± 11.1
		Δ (post-pre)	9.7 ± 15.1	2.8 ± 18.2
	Vigorous	Pre	37.0 ± 14.1	43.2 ± 12.2
		Post	48.8 ± 10.2	44.4 ± 12.8
		Δ (post-pre)	11.9 ± 21.0	1.3 ± 18.7
Lesson content	Management	Pre	7.8 ± 3.6	6.4 ± 2.7
		Post	2.6 ± 1.0 *	7.5 ± 1.8
		Δ (post-pre)	-5.1 ± 3.3 *	1.1 ± 3.1
	Knowledge	Pre	21.6 ± 9.0	21.2 ± 11.0
		Post	23.0 ± 7.1	17.9 ± 17.4
		Δ (post-pre)	1.4 ± 12.8	-3.3 ± 20.9
	Fitness	Pre	13.6 ± 19.2	19.7 ± 21.0
		Post	2.1 ± 4.0 *	12.1 ± 9.4
		Δ (post-pre)	-11.6 ± 18.0	-7.6 ± 18.8
	Skills	Pre	44.7 ± 26.2	39.7 ± 28.4
		Post	40.5 ± 12.5	31.4 ± 20.9
		Δ (post-pre)	-4.2 ± 28.6	-8.3 ± 30.1
	Game	Pre	11.9 ± 15.7	13.0 ± 17.9
		Post	31.8 ± 11.4 *	31.2 ± 32.9
		Δ (post-pre)	19.9 ± 16.5	18.2 ± 30.1
Coaches' interaction	Inside lesson topics	Pre	38.5 ± 12.5	33.0 ± 12.4
		Post	42.1 ± 11.8	38.0 ± 13.4
		Δ (post-pre)	3.6 ± 11.4	5.1 ± 9.4
	Outside lesson topics	Pre	0.0 ± 0.0	0.0 ± 0.0
		Post	4.4 ± 3.2 *	0.0 ± 0.0
		Δ (post-pre)	4.4 ± 3.2	0.0 ± 0.0
	No interaction	Pre	61.3 ± 12.2	67.0 ± 12.4
		Post	54.6 ± 14.5	62.1 ± 13.3
		Δ (post-pre)	-6.8 ± 13.0	-5.0 ± 9.3

Values (mean ± SD) are expressed in percentage of the lesson total time (%). IAC = instructors attending the training course; I-CON = control. Significant values: * = different than I-CON ($p < 0.05$).

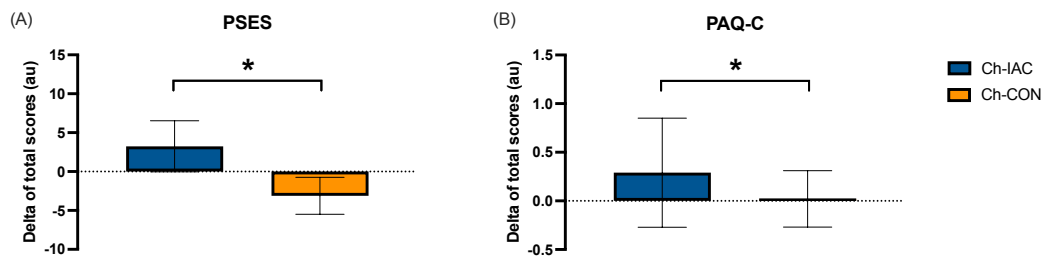
The children's testing sessions showed that Ch-IAC (i.e., the children of the teams of the instructors who attended the training course) outperformed Ch-CON in several parameters. In coordination skills, a significant interaction (time $\times$ group) was retrieved in the normalized motor quotient of the KTK ($F = 23.549$, $p < 0.001$, $\eta^2 = 0.056$), indicating that Ch-IAC had a higher normalized motor quotient than Ch-CON in the post-test (Figure 36, panel A). Similarly, Ch-IAC also enjoyed the activity more than Ch-CON: a significant interaction (time $\times$ group) of PACES questionnaire total score ($F = 94.463$, $p < 0.001$, $\eta^2 = 0.193$) was retrieved (Figure 35, panel B).

Figure 35. Time $\times$ group interactions in children's motor skills and enjoyment of physical activity. Panel (A): KTK (Körperkoordinationstest für Kinder) motor quotient; panel (B): PACES (Physical Activity Enjoyment Scale) total score. MQ = motor quotient; Ch-IAC = children from teams of instructors attending the training course; Ch-CON = children of the instructors' control group. # = significant time $\times$ group interaction ($p < 0.001$).



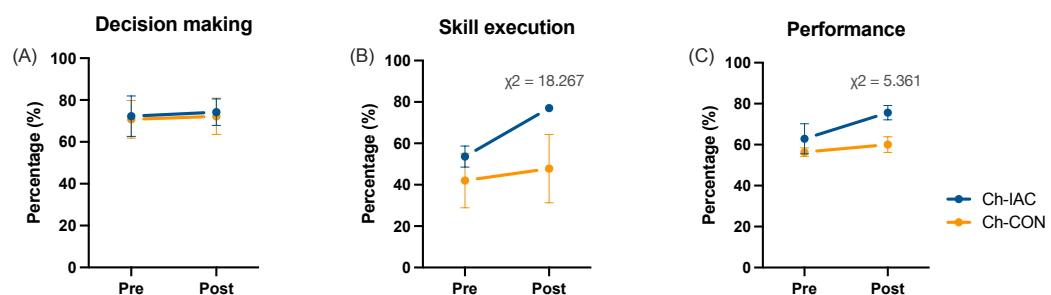
Instructors' participation in the training course considerably affected children's self-efficacy and physical activity levels. The analysis of delta values (post-pre) of PSES (Figure 36, panel A) showed that Ch-IAC positively increased self-efficacy compared to Ch-CON, which lowered ($p < 0.001$). Similarly, PAQ-C delta analysis (Figure 36, panel B) showed higher positive changes in Ch-IAC physical activity levels than Ch-CON ($p < 0.001$).

Figure 36. Children's self-efficacy and physical activity level variations (delta = post-pre values). Panel (A): PSES (physical self-efficacy scale for children) delta scores; panel (B): PAQ-C (Physical Activity Questionnaire for Older Children) delta scores. Ch-IAC = children from teams of instructors attending the training course; Ch-CON = children of instructors' control group. * = $p < 0.001$.



The match analysis through the GPAI instrument (Figure 37) showed an increase in Ch-IAC efficient skill execution and, consequently, in general match performance. No changes were detected between pre- and post-intervention decision-making.

Figure 37. Match analysis results by the game performance assessment instrument (GPAI) related to decision making (panel A), skill execution (panel B), and performance (panel C). Significant differences by the Chi-squared analysis are reported.



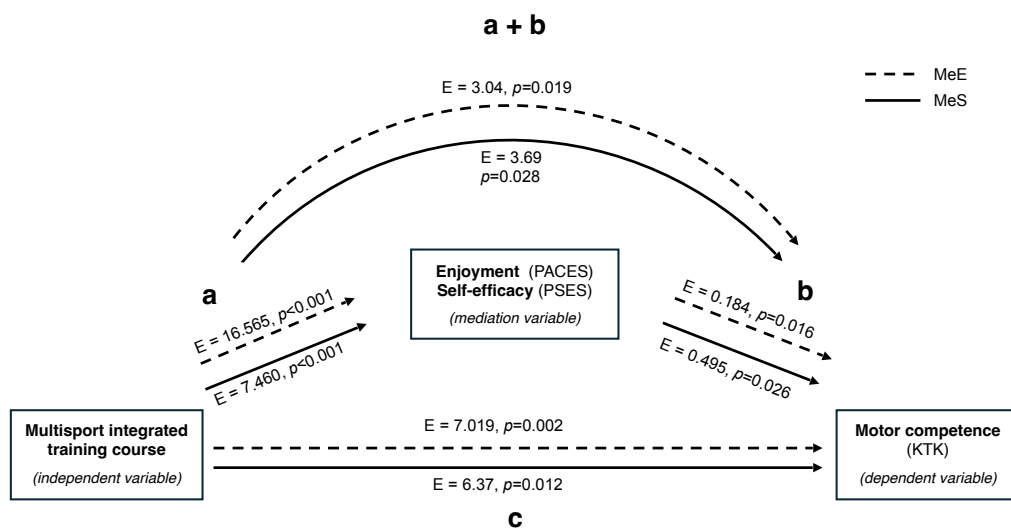
4.5.5. Mediation and Moderation Analysis

Figure 38 depicts the effects of enjoyment and self-efficacy as mediators in the relationship between independent (multisport-integrated training course) and dependent (motor competence) variables. The multisport-integrated training course had a significant effect on motor competence (c: $E = 7.019$, $p = 0.002$) and enjoyment (a: $E = 16.565$, $p < 0.001$). A significant effect of enjoyment on motor competence was found (b: $E = 0.184$, $p = 0.016$). The MeE, revealed that the indirect effect (a + b) of enjoyment is significant (a + b: $E = 3.04$, $p < 0.0019$), so the enjoyment mediates the effect of the intervention on motor competence. In the MeE, a significant total effect was detected ($E = 10.06$; $p < 0.001$). As in MeE, the direct effect (even if significant) resulted lower than the total effect; it is possible to notice that enjoyment partially mediates the effect of the intervention on motor competence.

The self-efficacy mediation analysis (MeS) revealed that intervention had a significant effect on motor competence (c: $E = 6.37$, $p = 0.012$) and Self-efficacy (a: $E = 7.460$, $p < 0.001$). A significant effect of self-efficacy on motor competence was found (b: $E = 0.495$, $p = 0.026$). The MeS, revealed that the indirect effect (a + b) of self-efficacy is significant (a + b: $E = 3.69$, $p < 0.0028$), so the self-efficacy mediates the effect of the intervention on motor competence. In the MeS, a significant total effect was detected ($E = 10.06$; $p < 0.001$). As in MeS, the direct effect (even if significant) resulted lower than the total effect; similarly to MeE, it is possible to notice that self-efficacy partially mediates the effect of the intervention on motor competence.

The PAQ-C mediation analysis (MeP) revealed that intervention had a significant effect on motor competence (c : $E = 9.66$, $p < 0.001$) and PAQ-C (a : $E = 0.317$, $p < 0.001$). No significant effect of PAQ-C on motor competence was found (b : $E = 1.28$, $p = 0.553$). In the MeP, a significant total effect was detected ($E = 10.06$; $p < 0.001$). The MeP, revealed that the indirect effect ($a + b$) of PAQ-C is not significant ($a + b$: $E = 0.405$, $p = 0.556$), so the amount of physical activity does not mediate the effect of the intervention on motor competence.

Figure 38. Flow chart of the mediation analysis. MeE = enjoyment mediation; MeS = self-efficacy mediation. a = effect of the independent on the mediation variable; b = effect of the mediation on the dependent variable; c = effect of the independent on the dependent variable (direct effect); $a + b$ = effect of the independent on the dependent variable mediated by the mediation variable (indirect effect).

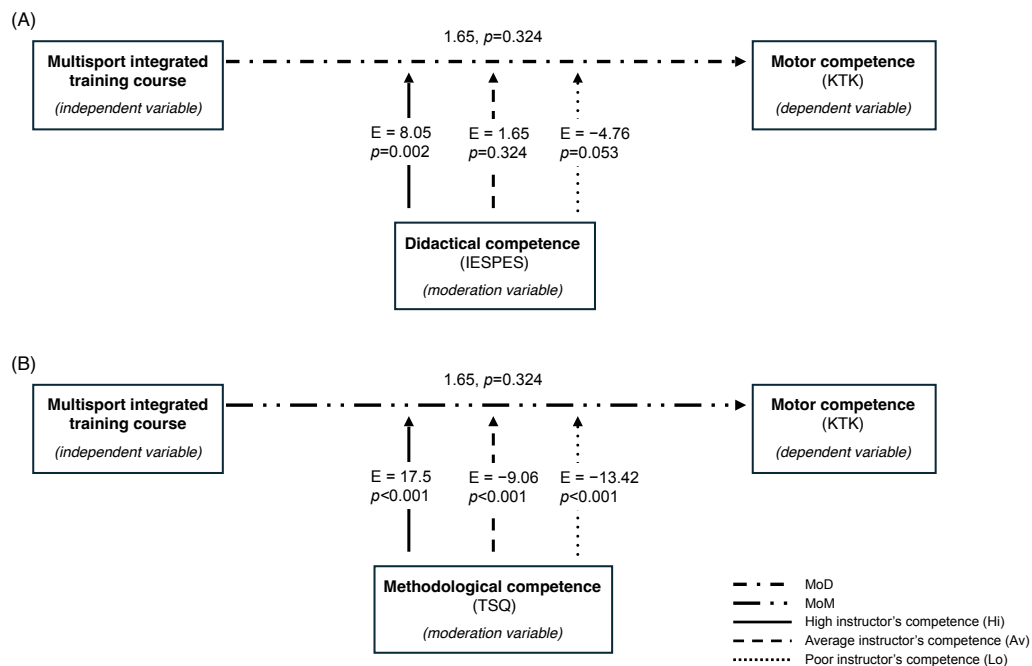


The moderation analysis (Figure 39) of didactical competencies (MoD) showed that a single multisport training course alone could not fully explain the DV results ($E = 1.65$, $p = 0.324$). Indeed, high didactics competence of instructors (Hi) positively influences the motor competence in children ($E = 8.05$, $p = 0.002$), an average instructor's didactics competence (Av) brought a little but not significant improvement in motor competence ($E = 1.65$, $p = 0.324$), and a poor or just sufficient instructors' competence in didactics (Lo) might lead to an aggravation of motor competence (Lo: $E = -4.76$, $p = 0.053$; Av: $E = -9.06$, $p < 0.001$). Furthermore, the MoD

interaction's effect shows that, for every increase in units in methodological competence, the effect of the intervention becomes more positive of 11.11 units ($E = 11.11$, $p < 0.001$).

About MoM, the higher the instructor competence (H_i), the higher the motor competence ($E = 17.5$, $p = 0.001$). Moreover, the MoM interaction's effect shows that, for every increase in units in methodological competence, the effect of the intervention becomes more positive of 5.94 units ($E = 5.94$, $p = 0.057$). Hence, as the number of teaching styles used increases, it partially moderates the effect of intervention.

Figure 39. Flow chart of the moderation analysis of the role of didactical competence (panel A) and methodological competence (panel B). MoD = didactical competence moderation; MoM = methodological competence moderation. In panel (A), the moderation analysis of the role of didactical competence (MoD) is shown., the full line refers to a high instructors' competence (Hi), the double-dashed line to an average instructor's (Av) competence and the dotted line to a poor instructor's competence (Lo).



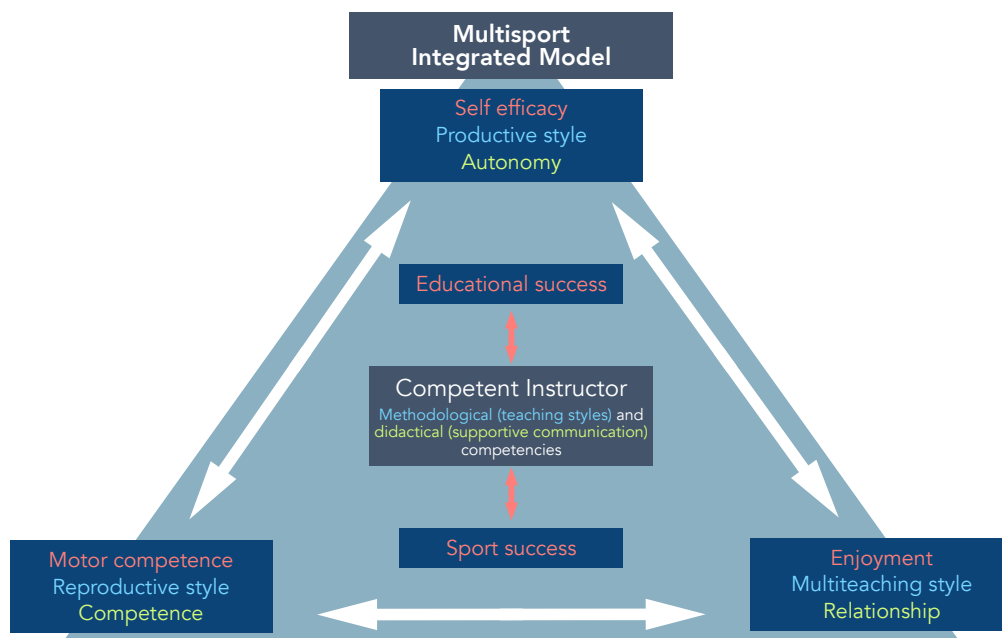
4.5.6. Discussion

The primary aim of this study was to investigate the effects of multisport-integrated model training, which a sample of rugby instructors (IAC) participated in. Thanks to training, IAC instructors significantly improved their didactic and methodological competencies, as evaluated through the internship evaluation sheet in physical education and sports (IESPES), the Instrument for Identifying the Teaching Style (IFITS), and the self-report referring to the Teaching Style Questionnaire (TSQ).

In the integrative multisport model we presented, educational and sports success are strictly related and depend on instructors' competence. Figure 40 graphically

depicts the multisport-integrated model and how educational and sports success are considered part of the same system. In educational and sports success, autonomy, competence, and relationship are the keys to supportive communication based on a pupil-centered approach. Teaching styles are related to autonomy (production styles centered on pupil), competence (reproduction styles centered on motor competencies), and relationship (multi-teaching based both on education in sport and through sport with adaptation to the needs of children). Autonomy, general competence, and relationships help build the children's psychological aspects (such as self-efficacy and enjoyment) and motor competence. A competent instructor based on methodological competence (teaching styles) and didactics competence (elements aimed to need supportive communication: communication capacity, motivation capacity, and didactic organization) is the core of this integrated multisport system.

Figure 40. The framework of the integrative multisport model: educational and sports success is strictly related to the key elements characterizing the need supportive communication integrated with the utilization of different teaching styles (autonomy, competence, and relationship). Both instructors and children are related to these key elements.



Based on the results of the IESPES instrument evaluating the internship's success, IAC improved total score, communication skills, didactics organization, motivation, and personal competence. These findings agree with Kirkpatrick (Kirkpatrick & Kirkpatrick, 2006), who found that pro-posing an adequate training course, alternating theoretical topics, debates, and internships with instructors and children could enhance instructors' didactic and methodological competence.

The self-reported teaching styles questionnaire showed that the IAC instructors used many more different teaching styles at the end of the multisport training course. Despite the frequent use of reproduction styles (70.9%), thanks to the training course, they learned to use production styles, such as those suggested by Da Silva, for team-oriented sports because helping children develop decision-making and playing skills (Bechter et al., 2019; Mesquita et al., 2012; Silva et al., 2020). Instructors improved their overall methodological competence by learning to manage the integration of reproduction and production teaching styles with the multi-teaching approach.

The use of an integrated multisport approach combined with methodological and didactical competence (as we considered through the statistical analysis of moderators) could improve socio-psychological aspects and self-awareness in children because it helps them develop autonomy, motor competence, and relationships with the pairs and adults (Deci & Ryan, 2010; Ntoumanis et al., 2017; Ryan & Deci, 2000).

The SOFIT's results about the conduction of physical activity performed by the pupils trained by IAC found a significant reduction in the children's time standing still (from 33.6% to 11.2% of the total lesson time) spent in the instructors' management (from 7.8% to 2.6%) and fitness (from 13.6% to 2.1%), and a significant increase in instructors' promotion of outside physical activity (from 0% to 4.4%). The decrease in the time spent standing still and in management presumably highlights that children were more involved in physical activity and, therefore, that IAC instructors found other strategies to manage the children, such as sitting during explanations (as the increase in time spent sitting evidence). Indeed, the sitting posture allows for a minor possibility of uncontrolled movement of pupils, generating less problematic and dispersive situations during group management, with fewer organizational difficulties, as the reduction in management time retrieved by both SOFIT (-5.1%) and IFITS (-19.7%) analysis confirms. The decrease

in the time spent on fitness (-11.6%) can be compensated by an increase in time spent on games (19.9%). According to Feigenbaum (Telama, 2009), children of this age should become fit and conditioned through different proposals, not only aimed at mere physical fitness but also through games that are more motivating proposals than mere exercises that make them highly involved and adequately conditioned. General conditioning by games could result in a lower perception of fatigue and higher motor control. These data, according to GPAI outcomes for execution skills and game performance, showed a possible improvement in IAC after the multisport training course because the more fitness (acquired by general games), the more precision in specific skills and effective performance. The integration of motor control in conditioning through games is the most effective way to reach a positive effect in situational sports performance due to an immediate transfer. Instructors also increased the promotion of outside activity (which was highlighted by the previous analysis with SOFIT) thanks to the multisport training course, as the increment of PAQ-C values of Ch-IAC confirms. These results demonstrate how a multisport-integrated approach contributes to the development of healthy lifestyles and public health and, therefore, to educational success based on physical literacy (Telama, 2009).

When addressing the effects of the multisport training of IAC on children's outcomes, this study's results evidenced significant differences in motor competence and game performance in favor of Ch-IAC compared to Ch-CON. The multisport-integrated approach positively influenced the motor coordination of children taught by IAC instructors, possibly because they proposed different types of activities and stimuli than I-CON, making the children more coordinated and motor competent. According to the literature, children who are stimulated to try different kinds of basic sports skills and activities are better supported in continuing motor and sports practice as they overcome the proficiency barrier (Brian et al., 2020; Popović et al., 2020; Stanković et al., 2023). As previously highlighted, considering the PAQ-C results, the multi-sport-integrated approach can increase the children's amount of physical activity as instructors increase the promotion of sports practice and the subsequent children's knowledge and the chance to choose additional sports activities in their free time (Condit et al., 2015; Invernizzi et al., 2019). Children who are not stimulated to vary motor skills and sports activities might not be able to acquire sufficient fitness at later ages.

Therefore, the results of the present study represent a valuable indicator of how such an approach based on multisport-integrated practice can positively impact the well-being and health of the children's future (Luukkainen et al., 2024; Moynihan & McMahon, 2014; Stodden et al., 2008).

The positive outcomes of PACES of Ch-IAC show that children enjoyed the multisport activities proposed and were involved in activities with different proposals that suit them best. The increase in PSES score Ch-IAC also demonstrates that the possibility to try different sports and learn different skills enhanced children's self-efficacy (Crouch et al., 2022; Gardner et al., 2017; MacIntosh et al., 2019; Pesce et al., 2013). Furthermore, given the positive outcomes from the instructors' questionnaire of satisfaction analysis, this educational training program results in a solid platform for sports and educational success. Considering this, instructors and sports societies should align their interventions with these findings (Kirkpatrick & Kirkpatrick, 2006).

The mediation and moderation analysis further investigated the effectiveness and transferability of the multisport-integrated training course on children. The results emerging from the mediation analysis showed that enjoyment and self-efficacy partially mediate the effect of the multisport intervention on motor competence, so they partially could amplify the effects on motor competence in children (Crouch et al., 2022; Pesce et al., 2013). The moderation analysis showed that different levels of didactical and methodological competence can improve or aggravate motor competence in children. The more the instructors' didactical and methodological competence, the more the children's motor competence; the less didactical and methodological competence the instructors have, the less the children's motor competence. For this purpose, the use of a need supportive communication integrated with motivational, personal, and organizational competence (didactical approach) and a multi-teaching approach (methodological competence) might improve the children's motor competence (Deci & Ryan, 2010; Invernizzi et al., 2019; Ntoumanis et al., 2017).

Using a multi-teaching style and active reflection approach, stimulated above all by greater use of productive styles based on question-delving into the "why" and "how" of human movement, is a way to encourage non-linear pedagogies. This way, it has been possible to administer a varied and non-linear approach by modifying task, environ-mental, or organismic constraints, therefore not

addressing what to do (as often authors claim in literature) but how to do it (increasing a diversified teaching styles approach), which ended in more significant effects on learning in the experimental group (Ch-IAC) compared to the control group (Invernizzi et al., 2019). The nonlinearity of learning processes must be interpreted holistically, considering not only the individual and the effects that a proposal could determine on the different personal areas but also the group in which the individual is inserted and the context that could determine the necessity of finding new ways to offering sports experiences in relation to the children's needs (Condello et al., 2021). Based on nonlinear pedagogy, a multisport approach stimulates variants integrated with the methodological ones related to teaching styles.

The literature evidenced how the acritical use of sports activities, caused by the implicit selectivity of the sport, is incompatible with an active long lifestyle (Baker, 2003; Malina, 2010). Also, a multisport interpretation, as a summary of different sports disciplines, not mediated by reflective practice and not contextualized, could lead to an excess of competition, which results in one of the most common causes of dropouts in youth (Hardman, 2003, 2005). Young athletes must be stimulated to reflect on their limits or competence, act reflectively, and self-check their practice through questions to avoid and prevent this problem.

Further consideration arises concerning the relationship between a nonlinear approach based on methodological competence (multi-teaching style practice) and the instructors' didactic competence related to supportive communication and organization of contents competence (Invernizzi et al., 2022). The notable relationship that emerged demonstrates how methodological and didactic competence are strictly related. The instructors' skills in varying teaching and sports approaches further let them acquire a better competence in supportive communication, organizational aspects of didactics, and lesson management. Using a nonlinear pedagogy by varying proposals through multisport and multi-teaching approaches and reflective practice (as presented in the training course that has been the object of the present study) can stimulate pupil-centered teaching with the aim to generate a children's task-oriented motivational climate essential to acquire adequate motor skills (Invernizzi et al., 2019; Jaakkola & Digelidis, 2007; Moy et al., 2016). Furthermore, a multi-teaching approach might favor the use of need-supportive communication and didactics organization through educational

experiences that satisfy children's psychological needs (autonomy, competence, relationship) necessary to lead to sports and educational success (Ntoumanis et al., 2017).

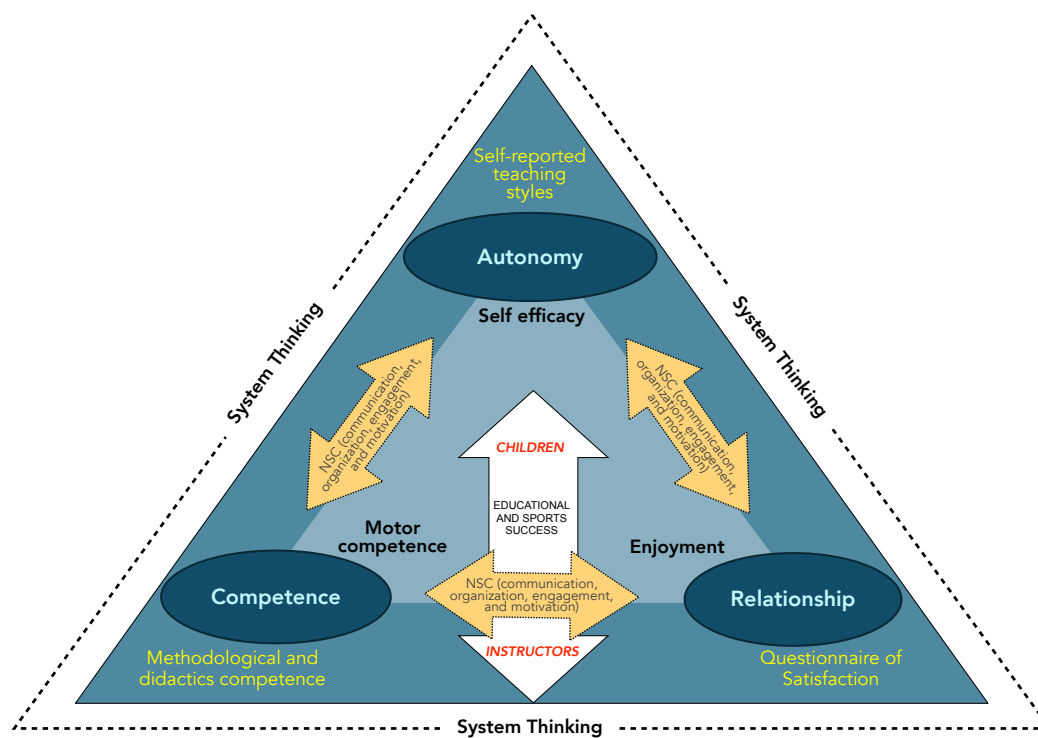
Regarding Vygotsky's zones of proximal development (Vygotsky, 2012), adapting teaching styles and communication methods to find the proper stimulation through a holistic perspective does not mean forgetting the technical aspects of the discipline but intentionally inserting them in the didactic-methodological approach to guarantee a more efficient acquisition.

Educational didactics in sports, long-lived and sustainable, do not focus on performance but must apply the different levels of motor competence through methodological and didactic strategies to embrace children's rights (David, 2004; Lang, 2022) and guarantee continuity of practice at group and sports club levels (Montesano et al., 2016; Robbins et al., 2021). Long-life sports practice is essential and should include inclusive didactics oriented to a progressive consciousness related to one's limits of competence and possible improvements, representing a concrete pillar of youth life and physical activity habits (Stodden et al., 2008). From this perspective, to move from an interpretation of sports disciplines as an objective to an interpretation aimed at educational purposes, training instructors' courses aimed at modifying the mentality, approaches, methods and teaching methods with which sports practice is traditionally proposed at a youth level becomes indispensable. The success of a youth instructor should not be evaluated through the performance obtained by children but in avoiding dropouts and promoting future continuity of individual practice by stimulating motivation to play sports in the current discipline or others.

Instructors' and children's systems are on the same plan and converge into a unique model, according to the system thinking approach (Figure 41), in which leverage, and resistance points can be individuated. Leverage points for both instructors and children are autonomy (self-reported teaching styles used and self-efficacy, respectively), competence (methodological and didactics competence, and motor competence, respectively), and relationship (questionnaire of satisfaction and enjoyment, respectively) (Rigon, et al., 2024). Resistance points can be the relationship between instructors and children and the actual vision of several Italian sports societies, which consider sports and educational success as detached systems, with the primary importance addressed to performance (Rigon, et al.,

2024). This model integrates instructors' and children's plans, builds a relationship based on a need for supportive communication and the vision of sports and educational success as attached parts and fundamental bases for constructing instructors and athletes of every category from childhood to adulthood.

Figure 41. Conceptual model of the instructor-children system of the multisport-integrated training approach and its investigation. The two triangles represent the instructors' (blue) and children's (light blue) systems. The fundamental topics of the need for supportive communication are shown at the vertexes. For every dimension (autonomy, competence, and relationship), this study assessed instructors' perception of the teaching styles used, methodological and didactic competence, and appreciation for the training course (yellow text). For the same dimensions, the children's self-efficacy, motor competence, and enjoyment were measured (black text). The children-instructor relationship is the basis of educational and sports success. NSC = need supportive communication.



4.5.6.1. *Limits of This Study*

In this study, the multisport model was limited to instructors interacting in a youth sports contest, not accounting for relationships with high-performance or amateur sports aimed at the well-being promotion of later ages. The model did not fully account for the possible conflicts that could emerge in the actual situation by converging the subsystems of competitive sport (ego-oriented, selective, and often considered primary in Italian reality) and educational sport (task-oriented based on an inclusion system). The conflicts between the two contrasting situations could generate an imbalance challenging to overcome in sports clubs (Berger, 2005).

The model also concerns the specific reality of rugby that cannot be generalized in other contests and sports disciplines. Based on the outcomes of this initial study, we can assert that the project's structure has the potential to shape our understanding of sports and sports associations in formative and educational terms. Notably, a multisport activity has been found to significantly enhance the children's motor competence and play capacity, leading to higher sporting success.

4.5.7. **Conclusions**

The rugby instructors attending a multisport-integrated training course considerably improved their didactic and methodologic competencies in conducting the sports activity with their pupils. The success of the multisport model (Figure 41) can be ascribed to having integrated the children's and instructors' domains related to the autonomy, competence, and relationship dimensions according to supportive communication, which, under the system thinking perspective, considers interconnections among setting, activity, and social dynamics variables of the minirugby environment. Participation, individual competence and performance of both instructors and minirugby players were favored by the multisport-integrated training.

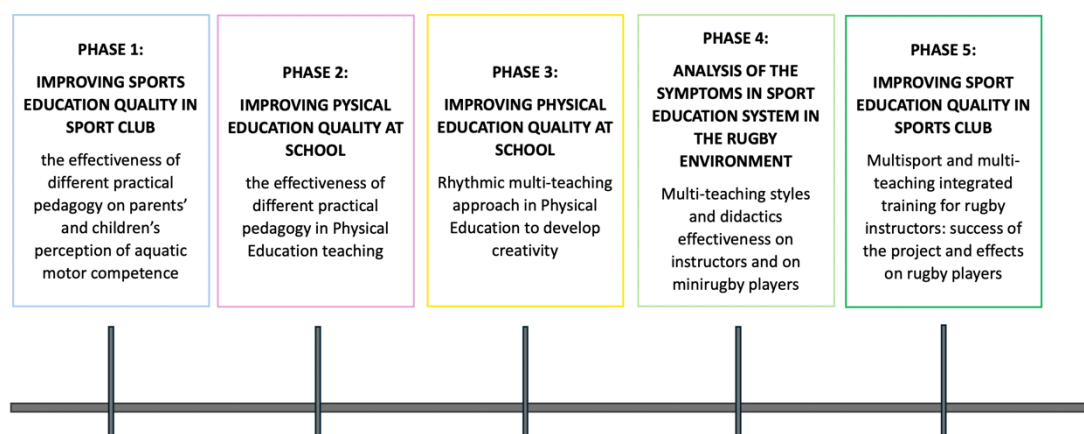
The future development of this type of research is represented by longitudinal studies extended to different sports disciplines and social realities, which can, in the long term, collect data/observations for comparisons between different environmental and cultural contexts.

V – GENERAL SUMMARY OF THE RESULTS

V - GENERAL SUMMARY OF THE RESULTS

Figure 42 summarizes the phases that characterized the verification of the sustainability of the ST of this project in the areas of school physical education and corporate sports educational practice

Figure 42. Thematic map of ST research in teaching approach in physical education and in sport education



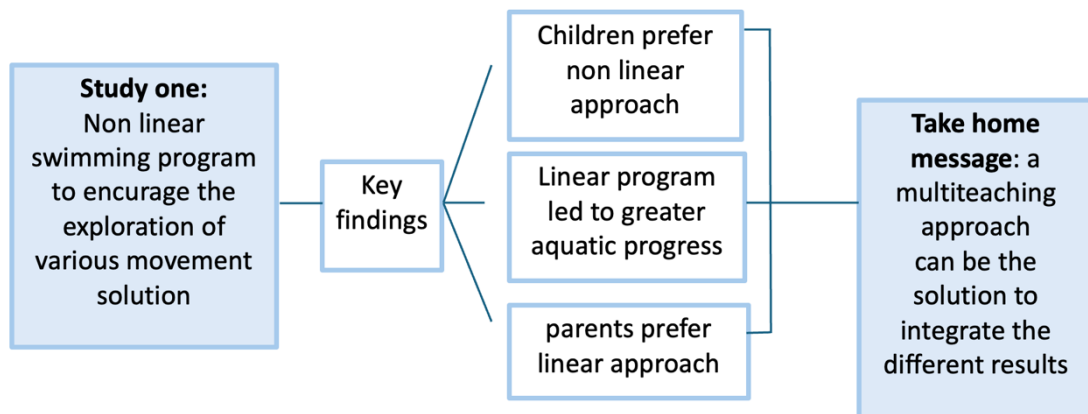
5.1. STUDY ONE

The analysis of the results of the first project showed that children preferred the non-linear approach, finding it more engaging, whereas the linear program led to greater progress and was deemed more rewarding by parents

5.1.1. Take home message study one

There is no ideal pedagogical approach in the sport training field, an integration of different methodologies is recommended. Figure 43 shows the summary of study 1.

Figure 43. Summary representation of study one

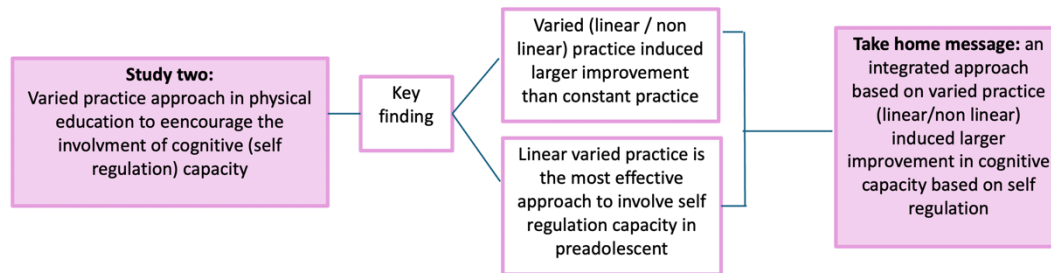


5.2. STUDY TWO

The analysis of the results of the second project showed the importance of varied practice to increase cognitive ability within physical education classes in preadolescents. Figure 44 shows the summary of study 2.

5.2.1. Take home message study two

Varied practice based on different methodologies is recommended during physical education lessons.

Figure 44. Summary representation of study two

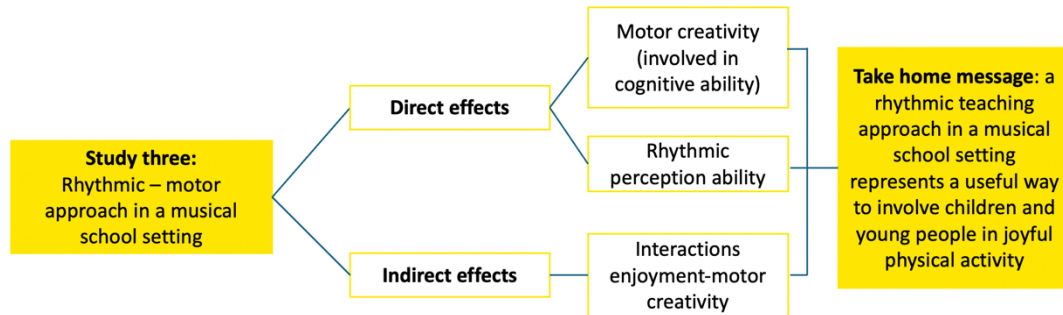
5.3. STUDY THREE

The analysis of the results of the project in a musical school setting highlights a direct effect of a rhythmic-motor approach, based on multiple teaching styles, on children's motor creativity and on rhythmic perception ability. Furthermore, enjoyment appears to be a factor in interaction with motor creativity. Figure 45 shows the summary of study three.

5.3.1. Take home message study three

A multiteaching methodology based on rhythmic teaching, in a school setting with a specific musical focus, represents a useful way to involve children and young people in joyful physical activity of both moderate and vigorous nature. An integrated practice involved different discipline as physical education and music is recommended to urge motor and mental capacity.

Figure 45. Summary representation of study three



5.4. STUDY FOUR

The analysis of the results of the project in the context of a rugby sports club, in its first preliminary diagnostic phase, highlights a didactic and methodological deficiency of the instructors, especially with regards to the use of production styles and motivating and engaging supportive communication. Some deficiencies are also highlighted in children's general coordination-motor skills and playing ability related to the cognitive capacity.

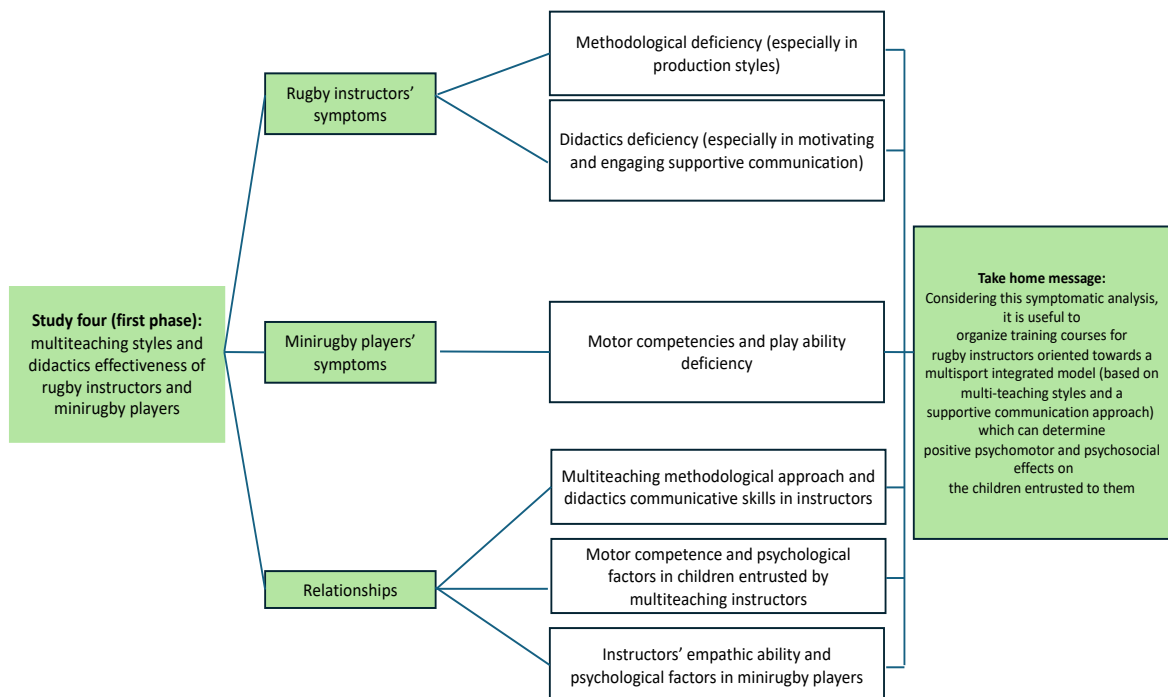
Relationships emerging between a multiteaching methodological approach and the didactic-communicative skills of the instructors, also highlighting relationships between motor competence and psychological factors (enjoyment, perception of self-efficacy) in the children entrusted to them. Teachers' empathic abilities are also correlated with the enjoyment and perception of self-efficacy of the children entrusted to them. Figure 46 shows a summary representation of study four

5.4.1. Take home message study four

Starting from this symptomatic analysis, it is considered useful to organize training courses for rugby instructors oriented towards a multi-sport and didactic-methodological approach (aimed at learning multiple teaching styles and the use

of supportive communication) which can determine positive psycho-motor and psycho-social effects on the children entrusted to them.

Figure 46. Summary representation of study four



5.5. STUDY FIVE

The second phase of the project within the rugby sports club, starting from the previous diagnostic phase, is oriented towards a multi-sport type course, integrated with didactic-methodological training, aimed at rugby instructors in the youth sector.

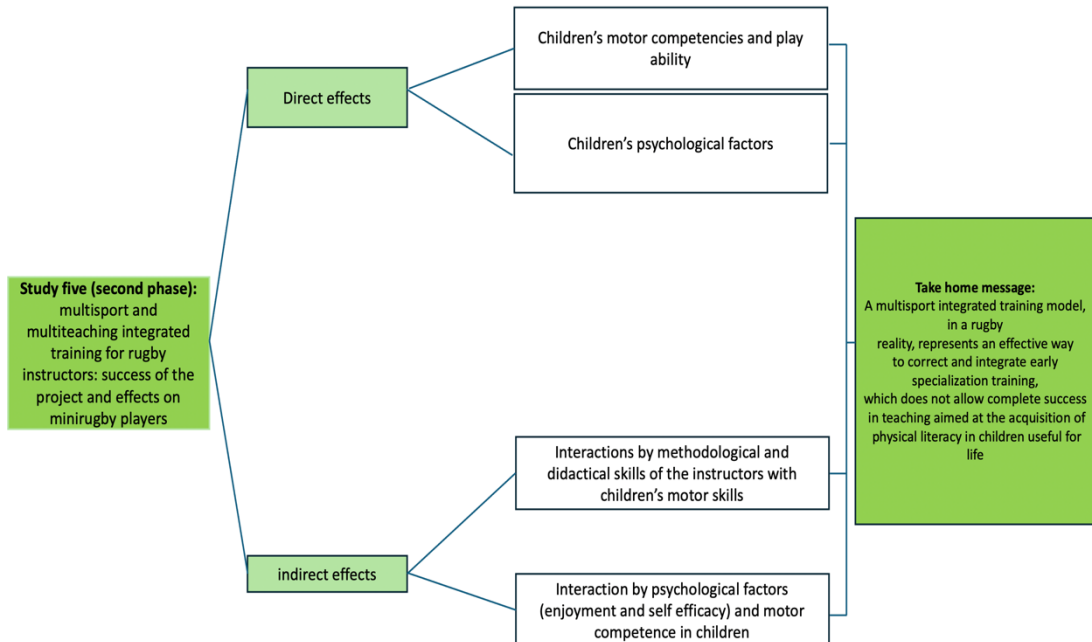
The analysis of the results of this intervention highlights a direct effect of an integrated multi-sport training approach on children's motor competence, their ability to play (related to cognitive capacity), general motor practice and

psychological factors. Furthermore, the methodological and didactic skills of the instructors, analyzed as moderators, highlight important relationships with the children's motor skills. Significant effects on motor competence are also determined by the psychological factors of enjoyment and children's perception of self-efficacy, analyzed as mediators. Figure 47 shows a summary representation of study five.

5.5.1. Take home message study five

A multi-sport integrated training of rugby instructors (proposed by Italian Motor Science Faculty), in a rugby sports reality, represents an effective way to integrate and correct an overly specialized training (typical of Federazione Italiana Rugby's courses) which does not allow a complete educational success aimed at the acquisition of physical literacy useful for life.

Figure 47. Summary representation of study five



VI – FINAL GENERAL REFLECTIONS

VI -FINAL GENERAL REFLECTIONS

System Thinking, as highlighted in this study with a vision related to educational complexity, represents an umbrella concept that aligns with the multi-causal dynamic approach of ecological theories in which the environment system plays a determining role (Chow & Atencio, 2014)

The common denominator consists of an open and innovative approach to physical education and sports pedagogy, focused more on the relationship (mesosystem) between the elements of the microsystem in which the child interacts, influenced by the different contexts (exo- and macrosystems), which allow the child's educative needs satisfaction (Bailey, 2005; Chow & Atencio, 2014; Kirk & MacPhail, 2002; Storey & Butler, 2013).

This approach is oriented towards the development of physical and sports education with experiences that go beyond the simple acquisition of technical-training skills and which are placed towards an indissoluble link with aspects of mental, emotional, social and physical well-being (Thorburn et al., 2011) not only based on scholastic or sportive success but also on formative success.

This way, Hopper (2010) describes the complex nature of learning as evolving "in a non-linear way" based on the exploration of constraints and ecological affordances (Hopper, 2010; Renshaw et al., 2010) interacting with the possibility and the need of the subjects involved for an educational physical and sportive process.

Sallis (Sallis et al., 2006) in his ecological approach considers the personal, social aspects, the physical, political, legislative and formative environment of reference in an integrated way.

Hastie (Hastie & Siedentop, 1999) highlighted the multiple and expanded concept of system by considering an organizational system (constituted for example by the school or sports club), a teaching system (of which the instruction

system, teaching and communication styles are part), a social system of students (based on relationships).

Each system influences and is influenced by the other, for example the instructor/teacher's didactical competencies create an effect on the students' behavior and the students' response, positive or negative and stimulates further responses of the teachers (feedback reinforcing or corrective loop). Furthermore, the teaching styles (methods) chosen by the teacher/instructors, can stimulate or inhibit their didactical skills and the supportive communication with retro effects on the children's learning.

Every change to one system affects the other two individually and in the social and organizational system (see Figure 49).

Merritt (Merritt, 1982) highlights the concept of "vector" attributing it to an action program that involves a set of components that interact, amplifying the result and extending it to other areas.

The primary vectors can be represented by the methodological and didactic aspects relating to the instructions, information, proposals, implemented by the teachers/instructors and aimed at the result of the project and action program.

The secondary vectors are made up of the responses implemented by the subjects of the educational process (by the children) as feedback and effect of the training.

Basing on this feedback information, the robustness of the primary vector and its possible remodeling of the organizational system are defined (Doyle, 1986).

SDT is a further theory that analyses a series of integrated socio-ecological factors such as autonomy, relationship and competence, which through adequate alignment can predispose, reinforce and enable physical-sporting practice.

Predisposing factors may include autonomy which has a positive association with physical-sports practice, as opposed to excessively controlled and directed practices which have a negative association with physical-sports practice. Reinforcing factors can be constituted by inter-element relationships based on positive reinforcement and the recognition of perspectives based on reference models. Enabling factors for motor-sports competence can be constituted by environmental and accessible resources based on facilities of associative organizational policies. For example, it is not possible from an equal opportunity

perspective to form a women's rugby team if, at a political-organizational level, there is no will to promote this practice, considering the low female presence (both in coaches and players) in studies 4 and 5. Thus, the possibility of extending the training process to both genders is limited (Hagger & Chatzisarantis, 2007; Ryan & Deci, 2000).

These general final reflections, based on the original theories and of their founders, are synthetize in Figure 48 and Figure 49.

Figure 48. Representation of System Thinking as “umbrella concept” that in a vision related to educational complexity, aligns with different approaches and concept

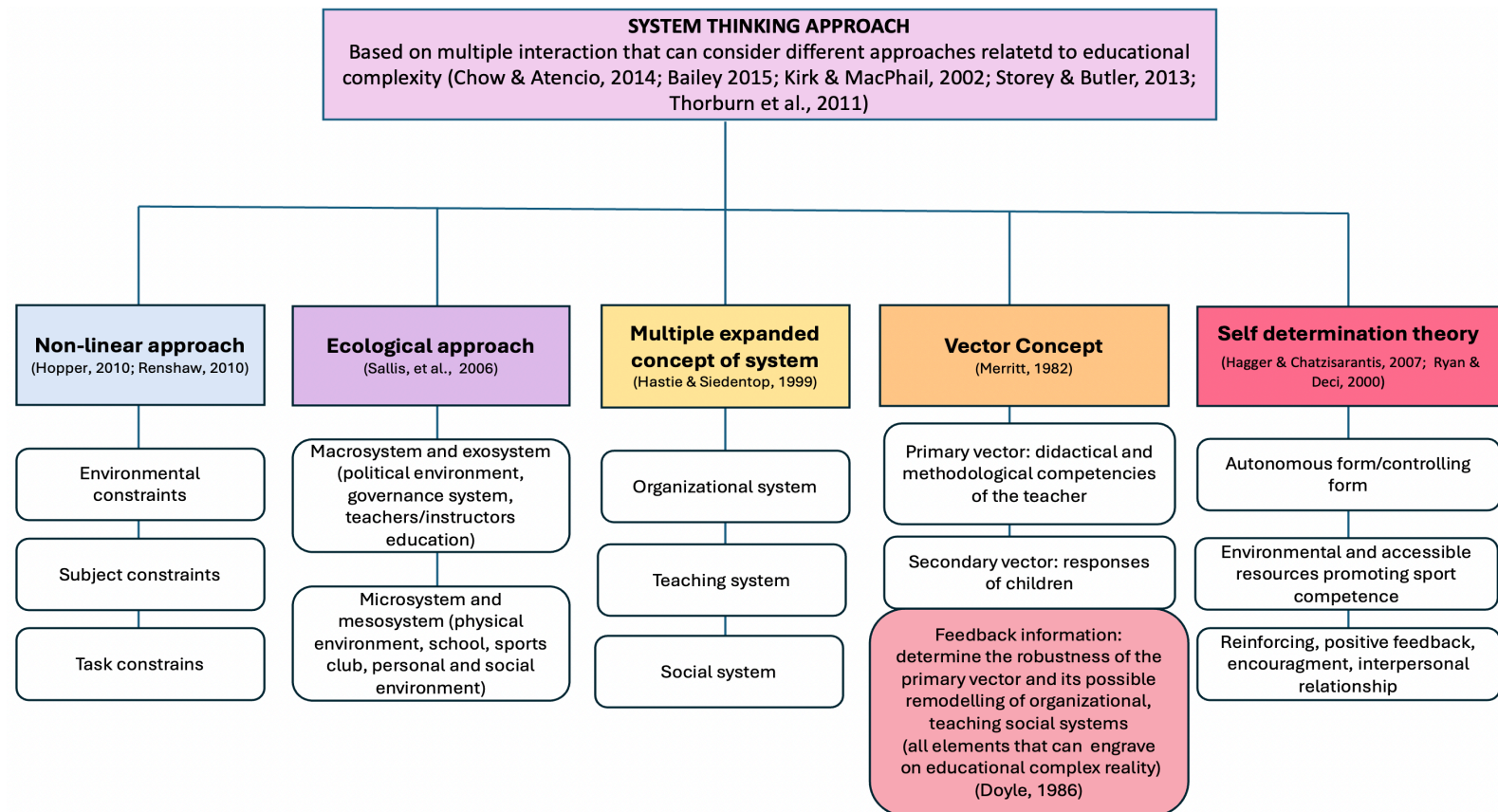


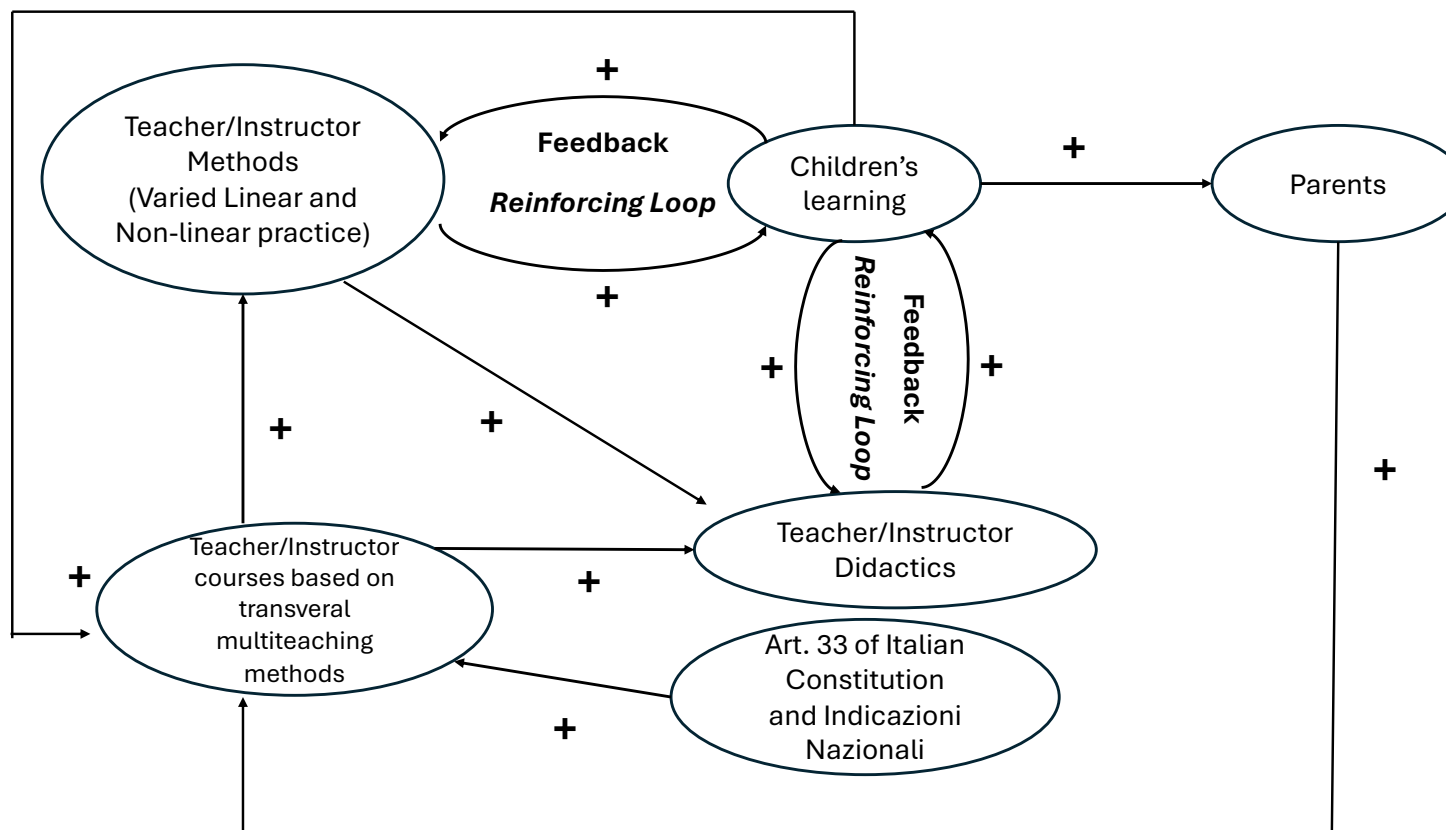
Figure 49. The paradigm of ST applied in physical education and in sport education

Figure 49 highlights the network structure of this work, which ensures the coherence and coordination of different areas, from the most external to the most internal system thinking and mutual relationships.

Analysis of this network reveals the sustainability of the whole system, which is based on circular actions of reinforcement and reciprocity. This helps us understand how different elements interact with each other.

These relationships in the presented studies have been mapped and analysed both quantitatively and qualitatively, and they have been applied to the complexity of motor-sport educational processes.

The system's reinforcing elements, based on the + symbol, highlight how, in this dynamic and circular context, the different elements support each other and interact.

These multiple and reciprocal relationships made it possible to detect the leverage points and reinforcing loops of this system, constituted by the varied and multi-teaching methods and the education of teachers and instructors as key points of the effectiveness of the general educational success of children, and not only sports and school success (exosystem).

Educational success should be considered an important element by institutions involved in the training of physical education teachers and sports instructors, consistent with the legislative references, of Italian Constitution and Indicazioni Nazionali (MIUR, 2012; Parlamento Italiano, 2023) (macrosystem).

In addition, the family context highlighted in study one (mesosystem), which is also oriented on an obvious demand for athletic success, represents an additional reinforcing element of a multi-teaching methodology that can meet the different needs of the overall reality to which it refers.

The System Thinking approach can be considered an objective, evidence-based approach that enables the identification of the most appropriate educational and methodological responses considering the needs and variables of the socio-cultural context referred to.

VII - REFERENCES

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VIII – ANNEXES

VIII - ANNEXES

ANNEX 1. Examples of contents and methods of activities by the pedagogies used.

NLP	VLP	CLP
No specific training on movement structure. Stimulation of functional aspects over constraints redirecting to the skills and abilities to be acquired.	Specific training addressing the movement's internal structure for learning sports basics.	Specific training addressing the movement's external structure for learning sports basics.
The teacher acts as a designer, organizes the affordances, and promotes actions by adequately setting the environmental constraints.	The teacher provides specific solutions to achieve success gradually and progressively through executive approximations, contrasts, and comparisons.	The teacher promotes segmented exercises of increasing difficulty that learners have to perform to manage the targeted skills properly.
The pedagogic fundamentals are perceiving, processing, and acting by selecting what and how to do a task.	Watching, judging, suggesting, and perceiving are the pedagogic fundamentals to master the movement, based on the internal processes of the central nervous system.	The primary educational feature is repeating the examples from the teacher many times to memorize and automatize the executions.
The teacher arranges varied environmental settings to arouse and produce adequate constraints to stimulate the functions connected to the specific targets. For example, a practice set to learn different positions and ways to manage balance relies on mats and benches. Object arrangements provide locomotory schema	The teacher provides the executive model, organizes the learners in pairs, gives them individual self-evaluation sheets to detect the key points of the required techniques, the errors, and the necessary correction process. Kinesthetic information and the body's proprioception is favored by an experiential approach, based on executive	The teacher provides a simplified task of the target movement that the learners have to repeat until learning occurs. Then, the teacher offers frequent technical, general, and individualized feedback to guarantee the task's error solution and correct execution. Once most of the learners have had success, the next step is

(climbing, passing, rolling, doing slalom, jumping) and object control (hitting, leading, throwing, catching). Eye patches or masks partially or completely limiting the vision is another example of an organismic constraint the teacher uses to force the learners' self-adaptations.

Further constraints involving tasks are considered: assignments to the primary running skill are added (i.e., counting, summing, spelling a word, combining different movements, making associations as kicking with the right leg when an animal is named, or left when a plant name is called).

contrasts and perceiving the experienced task's effectiveness.

After practice, the teacher promotes group analyses and comments on each pair's work.

proposed, possessing increased difficulty. This process recurs until the target skill is properly achieved.

ANNEX 2. Correlation analysis of enjoyment and self-efficacy with instructors' empathy and self-control

		PACES	PSES	Empathy Scale for Teachers				Self-control scale								
		Enjoyment	Self-efficacy	Total %	CE %	PAE %	NAE %	Total %	IC %	GS %	DC %	SM %	TI %	ER %	AU %	DM %
PACES	Enjoyment	1	,303**	,281**	0,135	,726**	0,019	0,094	,158*	-,202**	,296**	0,098	,322**	-,298**	0,105	-,255**
PSES	Self-efficacy		1	,397**	,288**	,288**	,223**	-0,107	-0,013	-,325**	-0,031	,296**	0,035	-0,092	0,092	-,324**
Empathy Scale for Teachers	Total %			1	,966**	0,056	,696**	-,398**	,175*	-,535**	-,588**	-0,046	-,226**	-0,083	,191**	-0,121
	CE %				1	-0,095	,658**	-,452**	,184**	-,551**	-,662**	-,194**	-,281**	-0,104	,177*	-0,037
	PAE %					1	-,397**	,446**	,208**	0,045	,666**	-0,095	,573**	-,212**	-0,084	-0,034
	NAE %						1	-,658**	0,033	-,382**	-,821**	,362**	-,750**	-0,079	-0,04	-,262**
Self-control scale	Total %							1	,249**	,725**	,803**	-,318**	,634**	,314**	-0,134	,629**
	IC %								1	,228**	,171*	-,597**	,141*	-,477**	-,657**	,439**
	GS %									1	,423**	-,237**	,143*	,156*	-,448**	,787**
	DC %										1	-,141*	,705**	0,012	-,162*	,182**
	SM %											1	-,340**	0,106	,230**	-,679**
	TI %												1	,153*	,338**	0,114
	ER %													1	,563**	0,113
	AU %														1	-,401**
	DM %															1

CE = Cognitive Empathy, PAE = Positive affective empathy, NAE = Negative Affective Empathy, IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision making. * = $p < 0.05$, ** = $p < 0.01$.

ANNEX 3. IESPES Items' Descriptors

Items	Descriptors ¹
Verbal communication	Comprehension; logic; choice of words of appreciation; choice of words of reproach; use of metaphors/narration.
Voice and paralanguage	Volume; Timbre; Modulation; expository rhythm; use of silences and pauses.
Non-verbal communication	Facial expression; eye gaze; eye contact; posture; proxemics gestures.
Specific didactics	Choice of exercises; progression; demonstration; correction; adaptation of the proposal.
Elements of organizational references	Location of tools; location in space of learners; safety/prevention/assistance rules; use of conceptual diagrams/charts/illustrations; time management (activity times; question times; organizational times).
Psychological references	Interest aroused; emulation level; expectations/requests; reinforcement; contextualization.
Personal competence	Charisma; accuracy; confidence; empathy; self-monitoring

¹ Instructors were evaluated on the five descriptors for each item. The descriptors were scored as 0 (=inadequate) or 1 (=adequate) point, returning a score ranging from 0 and 5 for each item. The final score was calculated as the mean of all item's scores.

ANNEX 4. Scientific studies



Article

Aquatic Physical Literacy: The Effectiveness of Applied Pedagogy on Parents' and Children's Perceptions of Aquatic Motor Competence

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Abstract: The goal of swimming school during early school age is to promote physical literacy. According to linear or non-linear pedagogy, a linear or non-linear approach teaching style can be used. The aim of our study was to investigate whether a different teaching methodology, as in using a teacher-centered approach (linear pedagogy), or a student-centered approach (non-linear pedagogy), could differently influence the perceptions of aquatic activity of children and parents. Parents of 100 children (53 females and 47 males, age 5.9 ± 0.3 years old) participating in the study were previously interviewed to ascertain their expectations regarding the swimming course. Participants were in a medium-high social context. Subsequently, considering the data of the incoming aquatic motor competence's tests, children were divided into a linear (LI) and non-linear (NL) pedagogy group. A total of 4 instructors were enrolled. Upon completing the swimming course, the aquatic motor competence's test was repeated, a pictorial scale of perceived motor competence was administered, and a questionnaire regarding the course was proposed to children's parents. Physical development and learn to swim resulted two of the most important reasons leading parents to choose swimming courses. LI achieved greater progress than the NL in actual motor competence (A.M.C.), while NL perceived a higher aquatic motor competence (P.M.C.) in 7 out of 10 items of the pictorial scale. Parents of children in LI, gave greater importance to the teacher's role, while NL's parents pointed the acquisition of children's abilities as pivotal. In conclusion, NL approach was more appreciated by children, while LI method was more rewarding for parents because initial expectations were satisfied.

Keywords: grounded theory; swimming; linear pedagogy; non-linear pedagogy

1. Introduction

The acquisition of good health practices, the awareness of the benefits of physical activity and the acquisition of motor skills are the basis for the development of appropriate motor literature leading to the maintenance of healthy behavior throughout life. Physical literacy can be described as the potential which everyone has in terms of motivation, confidence, physical competence, knowledge and understanding to assess and assume the responsibility for maintaining goals of physical activity throughout their lives [1].

Whether this potential is expressed or not depends on the motor competence, the actual physical activity carried out and the cultural context [1]. In this regard, each child needs to perform an adequate quantity of physical activity level in order to achieve the proficiency barrier, related to the adequate physical activity levels for health [2].

Water physical activity is a means for cognitive and motor development: practical and senso-motor intelligence constitutes the basis for the development of verbal and cognitive intelligence. It can be asserted that there's a continuity between intelligence and biological process of adaptations to the environment [3,4].

Through water practice, neuropsychic development of language [5] and children's personality are promoted [6,7], which can be used in the socio-relational sphere.

An early approach to aquatic environment allows an individual to become related to the outside environment with greater autonomy, decision-making independence and willingness. These skills enable the child to develop more self-confidence and promote the overcoming of fear, which could hinder the possibility to face new and unknown situations calmly [6].

In addition to psychosocial and cognitive development, swimming allows the development of strength, balance, flexibility, during the pre-scholar age [8], and the improvement of cardiovascular adaptation, leading to greater heart efficiency [9]. Swimming is therefore a useful skill for life and can promote the health status of an individual from a very young age.

The basis for learning aquatic motor competence are the development of movement, breathing and balancing techniques; altogether they constitute the bases for the safeness and comfort of an individual in the aquatic environment [10].

Balance in water is a skill to be acquired early because learning roll and body alignment, which promote good shoulder-shaped balance and reduce water resistance during moving, are more complex to internalize in adulthood [8].

Respecting the stages in learning swimming skills is very important: children until 5-years-old need a long period of psychological adaptation to the aquatic environment before being able to move with confidence and acquire specific skills [11]. Interaction with peers and the teacher will allow the development of languages and social skills as they become more self-confident. According to the social constructivism theory [12,13], cooperative learning in small groups facilitates the learning through the observation of the peers. Likewise, swimming instructor's social competences are also fundamental to establish a relationship within the group [14]. Social competences could stimulate both child attention and curiosity, through an active involvement, and identify what the child already knows and what it is necessary that she/he learns. This process requires the teacher's observation [15] and the consequent supply of appropriate feedback to consolidate what has been previously learned.

In this context the teacher's role is more or less evident depending on the methodological approach that is used: "It is not sure which is the best teaching method, but it is clear that the most efficient program is one that respect each characteristic of the child, which are unique" [16]. The goal of the swimming school during early school age is to promote physical literacy [1]. In this respect, the choice of the teaching style to adopt could be directed towards a linear approach (linear pedagogy) [17]. With this method the instructor-facilitator proposes different activities based on imitative approach. This criterion is peculiar of reproductive styles, in which are determined a transfer of information as in the cognitivist approach [18], through the active interaction and the collaboration with the learner. Alternatively the approach can also be non-linear (non-linear pedagogy) [17]. It is an ecological-dynamic method based on productive styles in which the facilitator prepares the material in order to create new situations and intervenes when is occurred, without providing instructions to the group. Motor creativity and students' autonomy are stimulated by the environment [19]. This allows the child to express himself freely and at the same time to address her/him towards a new motor representation of her/his body related to an environment which requires an important adaptation to the terrestrial motricity.

Even though there is no one teaching style better than another [16], we find it interesting to consider and investigate parents' and children's perceptions about their acquired competences through the use of the two teaching styles. Our researching field regards

the scope of physical literacy and personal autonomy, the relationship between child and aquatic environment and the impact of the figure of the instructor both from a psychosocial and an organizational point of view. Starting from the survey concerning to the aquatic motor culture of the parent, the aim of our study was to investigate whether a different teaching methodology may influence, in a different way, the perceptions of aquatic activity of children and parents.

2. Materials and Methods

2.1. Participants and Context

A total of 100 children (age 5.9 ± 0.3 years old), 53 females and 47 males of a medium-high social context, with their parents, participated to the study for fifteen weeks, by organizing the activity into two weekly lessons of 50 min duration each. A total of four instructors were involved in the study, two for the linear pedagogy group (LI) and two for the non-linear pedagogy group (NL). During lessons instructor/children ratio was 1/8.

Eight children were excluded from the study due to their incomplete enrolment in the course, 5 for LI group and 3 for NL group.

To be included in the trial, children had to be 5–6 years old. Conversely, having previous swimming experience or having cognitive or motor disorders were considered as exclusion criteria.

An informed consent was signed by the parents before participating in the study and the trial was approved by the Ethics Committee of the University of Milan (protocol code 2/12).

2.2. Procedure

The parents of the children who participated in the study were interviewed in advance with the aim to express their expectations regarding the swimming course.

After the interview, children were divided into two groups considering the data of the incoming aquatic motor tests in order to obtain two groups with equal aquatic motor competence.

Linear pedagogy group (LI) was composed of 50 children, 23 females and 27 males (height 116 ± 6 cm; weight 22.7 ± 4.1 kg; Body Mass Index (BMI) 16.8 ± 2.3 kg/m²), the non-linear (NL) one was composed by 50 children, 30 females and 20 males (height 116 ± 6 cm; weight 21.4 ± 3.5 ; BMI 15.9 ± 1.4 kg/m²).

The groups were homogeneous at the baseline for the value of Langerdofer–Bruya [15] actual motor competence test.

LI group and NL (Table 1) group were involved in a period of swimming learning using linear and non-linear teaching styles, respectively, and at the end they were subjected to the aquatic motor tests again to verify which group had more benefits concerning actual motor competence. The two groups performed the lessons in pools with similar characteristics (shallow water; water temperature = 30 °C; environment temperature = 25 °C). Subsequently, the parents of the children in both groups responded to a multiple-choice questionnaire in order to verify the teaching style influence in parent's perception of the swimming course. To evaluate the children's self-perception at the end of their swimming course, children completed the pictorial scale of perceived aquatic competence.

2.3. Information Collection

2.3.1. Preliminary Interview on Swimming Course Perception through the Grounded Theory (GT)

A preliminary interview was given to the parents of the children participating in the trial and was conducted according to the Grounded Theory's model [22]. This approach involves a semi-structured interview that starts from the research questions and develops through the answers and argumentation of the interviewees. Therefore, no pre-defined questions were provided, but rather a general initial question from which different questions were developed according to the answers given by the respondents. The purpose

of the interview was to investigate the aquatic motor culture of the parents. After this first phase, the coding of the answers was shared. In the first step of the opened coding, the themes called as pre-labels were extrapolated, those which expressed similar concepts were grouped in single theme defined labels. After the opened coding, the axial coding was done, dividing labels into categories, and quantifying them according to how often they appeared in the interviews. The labels appearing with a frequency less than 50% were defined as sporadic, the labels appearing with a frequency between 51% and 70% were defined as typical and the ones appearing with a frequency more than 71% were defined as general. From these, the Core Category was extrapolated, i.e., the emergent category. The answers were grouped regardless the child belong to the LI or NL group, and before the assignment to either group.

Table 1. Comparison of the main methodological principles regarding teacher-centered (LI) and student-centered (NL) pedagogies.

Methodological Principles	
Teacher-Centered Pedagogy [20] Linear Group	Student-Centered Pedagogy [21] Non-Linear Group
Specific training aimed to immersion, buoyancy and propulsion	No specific training aimed to immersion, buoyancy and propulsion
Proposals due to a physical effort of the child (muscular, cardio-respiratory)	Discovery of the aquatic environment for a own initiative and not as a result of a external imposition
Proposals aimed to promote a rapid autonomy and independence in water	Ludic interaction between children and between children and teacher
The instructor stimulates and proposes specific exercises aimed at a gradual and progressive conquest of the aquatic environment	Respect for the child, for his/her emotional reaction and learning rhythms
Use of the metaphors and imitative exercises. Gradual progression of exercises aimed at the learning of a specific operative goal at a time	Teaching aids and materials as stimuli of learning. Randomized a varied multilateral approach aimed at testing multiple motor possibilities simultaneously

2.3.2. Aquatic Motor Competence

Children were involved in aquatic motor tests to identify their initial level of actual motor competence. The same tests were repeated at the end of the course with the aim to verify the progresses achieved after the intervention. In this regard, the Langerdofer-Bruya [15] test was used, in order to investigate the water entrance capacity, the immersion, the breathing, the buoyancy, the movement of the arms, the recovery of the arms, the movement of the legs and the arms-legs coordination. The entrance in water with different orientations and the body's inclination in water were not considered. The test was proposed by two neutral experienced researchers in this field, authors of this study, and not directly involved in the teaching.

2.3.3. Parents' Questionnaire (PQ)

After the intervention with the two teaching styles, a questionnaire with 12 multiple-choice questions was proposed to the parents, in which they had to give his/her opinion regarding the swimming course perception. The questions were structured on the basis of the answers obtained in the first interview with the grounded theory method and related to the three thematic areas emerged: physical literacy (PHY; 3 questions), child-aquatic environment relationship (CHI, 4 questions) and instructor (TEA, 5 questions). Physical literacy area regards what the swimming school teaches to the children in terms of wellness, confidence and specific competence; the children area refers to which aquatic competence the child achieves and learns from the course; the teacher area encloses all the aspects which can influence or promote through the teaching style adopted. Each question presented 4 possible answers, of which there were 2 negatives and 2 positives. Finally, the answers regarding positives perceptions of the parents were grouped and compared.

2.3.4. Pictorial Scale of Perceived Aquatic Motor Competence (PS)

After the intervention with the two teaching styles, a pictorial scale of perceived aquatic motor competence was proposed. The questionnaire designed by Murcia and Ruiz Perez [23] is composed by 10 items in which it is possible providing an answer between the three choices and each option has a referred image in order to be easily understood by the children [23]. The questions referred to different scopes of aquatic motor competence also grouped in three thematic areas as the relationship with the swimming pool environment (related to aspects such as autonomy and motivation, typical goals of the physical literacy; questions 1 and 2), water competence (in which children's perception in specific aquatic motor competence and his relationship with the aquatic environment are investigated; questions 3, 4, 5, 6, 7 and 8) and psychosocial aspects related to the performance and relation with peers, (questions 9 and 10). Each response regarded a different level of the perception of the competence (A = high, B = medium; C = low); for the comparison made, positive answers (level A and B) were considered.

2.3.5. Attribution of Colours

In order to differentiate the analysis' approach, in Figures 1–5, we have considered three different colors (arbitrarily chosen) as Grounded Theory method suggests, for a better recognition of categories and thematic areas [24].

In this regard we decided to allocate the dark grey to the answers related to the concept of physical literacy, the light grey to the aspects related to the personal aquatic motor competence of the child, and the white to the answers distinguishing the sphere of the teacher.

2.4. Data Analysis

A mixed approach with predominant-qualitative approach for this study was used, in order to combine and integrate the physical aspects, such as aquatic motor competence, and social and psychological aspects, such as parents' and children's perceptions.

2.4.1. Qualitative Analysis

A qualitative analysis approach for the results of preliminary interview was led, according to Grounded Theory methodology. Furthermore, parents' questionnaire and children's perceived motor competence were administrated as explained previously.

2.4.2. Quantitative Analysis

To analyze the pre-post intervention changes measured with Langerdofer-Bruya test, the non-parametric Wilcoxon test was used, while the Mann-Whitney test was used for delta comparison. For all performed analyses, was considered an $\alpha = 0.05$. Then the Effect Sizes (ES) were calculated using Phi (ϕ) and r^2 . Coefficient of variation (expressed as a percentage $CV\% = (\text{Standard Deviation}/\text{Mean}) \times 100$) was calculated in order to identify the intra and intergroup homogeneity.

3. Results Qualitative and Quantitative Analysis

3.1. Preliminary Semi Structured Interview Proposed to the Parents, Qualitative Analysis

According to the Grounded Theory Method, results can be represented through schemes, as shown below in Figure 1. The diagram illustrates the themes that emerged from semi-structured interview set up with parents, starting from the research question.

Analysis shows that **physical development** resulted in one of the most important reasons that led parents to choose swimming courses (86%). The idea often is enforced by the pediatrician: "The doctor advised us swimming during the growing phase because (it) is the best sport" (interview n.12), "Since my son has flat feet and is a little bit overweight, the pediatrician advised me to take him to the swimming pool" (interview n.13).

Parents considered the swimming course as a proper teaching tool because the discipline required into the aquatic environment can be conveyed through the game: *“In my opinion swimming can be taught with a playful key, even though concentration is required”*.

The category **acquired good water skill and learning to swim (83%)** represents the main motivation for parents to enroll their children in the pool in order to acquire a good swimming technique: *“I would like her to learn swimming very well, to become a good swimmer, which I’m not.”* (interview n.34), *“We started early because it’s difficult to learn, you must have a precise technique for breathing and coordination of the movements”* (interview n.63). Those who acquired familiarity with water, wanted their children to follow their same example: *“I wanted her to have a beautiful aquaticity since she was a child, to love water like I do.”* (interview n.2), *“I decided for swimming because his father is very sporty, so they can swim together”* (interview n.29).

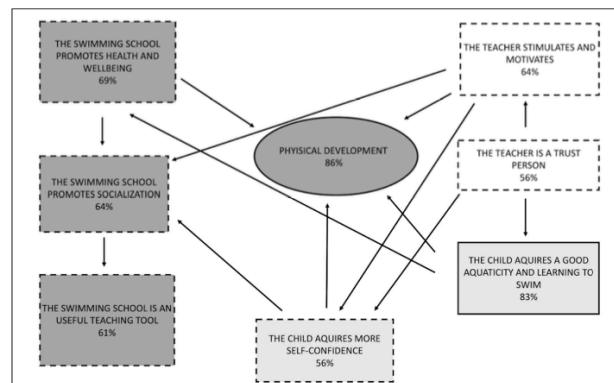


Figure 1. Representation of the themes emerged from the semi-structured interview with parents about considerations related to swimming school and swimming course attended by the children. The core category is represented at the center, in the ellipse with the continuous edge. Rectangles with continuous edges represented the category with the most frequent labels (>75%), those with dashed edges the category with a frequency between 50% and 75%. The dark grey indicates physical literacy’s dimension, the light grey stands for the children’s size, and the white is associated to the instructor’s sphere. The categories with a less frequent labels (<50%) were not considered in the study.

A state of well-being and health contributes to guaranteeing a child’s physical development regarding the physical literacy dimension, while acquiring more self-confidence constitutes the base to guarantee a good physical development of the child. Physical development is also influenced by the instructor who must be able to stimulate and motivate the child. *“I hope my daughter always grows up with people which could passionate her to sport”* (interview n.35), *“The instructor who gratifies my daughter is a good thing”* (interview n.7).

The relationship based on trust between instructor and child is decisive for the acquisition of a good aquaticity and consequently also for the physical development which happens through aquatic environment: *“The child confidence in instructor is crucial”* (interview n.12), *“the parents in more comfortable if he sees a good teacher”* (interview n.3).

The swimming school is considered as a means to improve and wide the possibility of promoting the socialization and relationship with peers. Sometimes this need is encouraged by the parents: *“I would like my son, through the swimming course, learning to approach with the others feeling at ease”* (interview n. 24), *“Learning to stay in a group and find new friends”* (interview n.20) overall for the lonely and shiny children who have difficulties with social

relationships: “My son is a bit lonely so they recommended us an activity with other children” (interview n.93) and sometimes this need is searched by the children themselves, who joined the swimming school because of the attendance of their friends: “He decided himself, probably because of his two school mates who already attended the swimming course, so he wanted to attend it too” (interview n.70).

3.2. Quantitative Analysis Related to Actual Aquatic Motor Competence Tests of the Children

Pre- and post- intra-group results of the linear group (LI) and non-linear group (NL) and inter-group (LI vs. NL) results are shown in Table 2.

The pre- and post- comparison of LI and NL group showed that children improved overall. A more detailed analysis of the LI group showed that children improved all the skills investigated except for water entry, for which no statistically significant differences were emerged.

Within the NL group, appreciable improvement were encountered in competence related to buoyancy, arm propulsion action, and arm recovery action. The comparison between LI and NL showed that, the LI group reached greater progresses than the NL group, particularly in terms of buoyancy, arm propulsion action, and combined movement. NL group, on the other hand, reached greater progress in arm recovery action and in the homogeneity intragroup evaluated with CV%. Considering this last result, NL group has achieved a greater homogeneity at the end of the swimming school (CV% = 12.2%) than the LI group (CV% = 17.9%). In particular for “Breathe control and immersion” (CV% from 18.3% to 12.5%), “buoyancy” (CV% from 39.8% to 21.7%) and “leg propulsion action” (CV% from 40.8% to 21.7%) the NL group increased the homogeneity, which is an indicator of an effective learning. LI group increased the non-homogeneity in all the items except in “water entry” (CV% from 14.3% to 9%) and in “buoyancy” (CV% from 34.5% to 20.6%).

3.3. Global Results Emerged at the End of the Swimming Course in LI e NL Pedagogy Group Related to the Expectations of the Parents and the Perception of the Children

Results emerged from GT are shown in Table 3. Data are presented as percentages.

3.4. Specific Results Related to the Parents’ Perception Questionnaire Post Intervention, Qualitative Analysis

The results of the parents’ questionnaires are showed below. Figure 2 presents the diagram according to Grounded Theory that illustrates the results of the questionnaire which the parents of LI group children were subjected to.

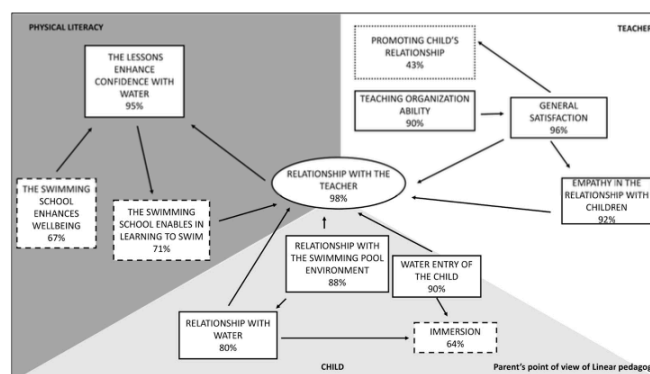


Figure 2. Diagram related to the parents’ perception of LI group as revealed by the administered questionnaire.

Table 2. Results of Pre and Post Langerdofer-Bruya aquatic motor competence tests, expressed as mean $\pm$ standard deviation. Statistical differences ($p < 0.05$) of intra-group analysis are reported in Pre vs. Post columns. Statistical differences ($p < 0.05$) of inter-group analysis are reported “LI vs. NL pre” and “LI vs. NL Δ ” columns. ES = effect size. * $p < 0.05$.

	Linear						Non-Linear					
	Pre			Post			Pre vs Post			ES (r^2)		
	Pre (A.U.)	Post (A.U.)	Δ (A.U.)	Pre (A.U.)	Post (A.U.)	Δ (A.U.)	Pre vs Post	ES (r^2)	LI vs. NL Pre	ES (ϕ)	LI vs. NL Δ	ES (ϕ)
Water entry	2.8 $\pm$ 0.4	2.9 $\pm$ 0.3	0.1 $\pm$ 0.4	3.0 $\pm$ 0.2	3.0 $\pm$ 0.1	0.0 $\pm$ 0.3	0.059	0.040	0.023 *	0.058	0.143	0.024
Breathe control and immersion	2.8 $\pm$ 0.4	3.2 $\pm$ 0.5	0.5 $\pm$ 0.7	2.5 $\pm$ 0.5	2.9 $\pm$ 0.4	0.2 $\pm$ 0.5	0.001 *	0.131	0.166	0.022	0.138	0.025
Buoyancy	1.6 $\pm$ 0.5	4.0 $\pm$ 0.8	2.5 $\pm$ 1.0	1.7 $\pm$ 0.7	3.4 $\pm$ 0.7	1.7 $\pm$ 0.9	0.000 *	0.357	0.674	0.002	0.001 *	0.129
Arm propulsion action	1.0 $\pm$ 0.0	2.3 $\pm$ 0.4	1.3 $\pm$ 0.4	1.0 $\pm$ 0.0	2.0 $\pm$ 0.0	1.0 $\pm$ 0.0	0.000 *	0.388	1.000	0.000	0.000 *	0.163
Arm recovery action	1.0 $\pm$ 0.0	2.3 $\pm$ 0.5	1.3 $\pm$ 0.5	1.0 $\pm$ 0.0	2.5 $\pm$ 0.5	1.5 $\pm$ 0.5	0.000 *	0.385	1.000	0.000	0.048 *	0.044
Leg action	1.0 $\pm$ 0.0	3.2 $\pm$ 0.5	2.2 $\pm$ 0.5	1.1 $\pm$ 0.4	3.1 $\pm$ 0.7	2.0 $\pm$ 0.7	0.000 *	0.381	0.355	0.010	0.146	0.024
Combined movement	1.0 $\pm$ 0.0	2.5 $\pm$ 0.6	1.5 $\pm$ 0.6	1.0 $\pm$ 0.0	2.4 $\pm$ 0.5	1.4 $\pm$ 0.5	0.000 *	0.369	1.000	0.000	0.248	0.012
Total	11.2 $\pm$ 1.4	20.5 $\pm$ 3.7	9.4 $\pm$ 2.6	11.3 $\pm$ 1.1	19.1 $\pm$ 1.3	7.8 $\pm$ 1.4	0.000 *	0.352	0.725	0.001	0.008 *	0.08

Table 3. The Table is divided into three thematic areas. On parents’ perception side, the first line refers to the physical literacy’s sphere, the second line is related to the child dimension and the last one regards with the aspects of the instructor. On children’s perception side, the first line refers to the relationship with the pool environment, the second one is related to the water competence and the last one regards with the psychosocial aspects. The three categories of parents’ perception emerged from the results of GT, of which the questionnaire has been structured on. The three categories of children’s perception have arbitrarily made to correspond to the emerging GT categories. The percentages considered refer to positive responses.

	Percentage Data Are Shown below (Table 3). Education					
	Parent’s Perception			Child’s Perception		
	LI	NL	LI	NL	LI	NL
Physical literacy (PHY)	1.1. Do you think that the swimming school has been beneficial for the health, the physical development and the wellness of your son/daughter? A. Yes, completely B. Yes, partially C. Not at all D. No, I don’t.			1. At the swimming pool, how do you put your swimming costume, hat and bathing shoes on? A. I do it myself B. Sometimes I do it myself C. My teacher always helps me		
	67%	80%	Relationship with pool environment (PHY)	60%	80%	
	1.2. Do you think that the swimming course has enabled your son/daughter to learn the swimming technique? A. Yes, completely B. Yes, partially C. Not at all D. No, I don’t.			2. How do you feel when you go to the swimming-pool? A. I love going to the pool B. It’s hard to go to the pool C. They make me go to the pool		
	71%	29%		70%	93%	
	1.3. Do the lessons proposed allowed your son/daughter to have a greater confidence with water and swimming pool environment? A. Yes, completely B. Yes, partially C. Not at all D. No, they don’t.					
	95%	80%				

Percentage Data Are Shown below (Table 3). Education

Percentage Data Are Shown below (Table 3). Education				
	Parent's Perception	Child's Perception		
	2.1. How does your son /daughter relate in the swimming pool environment? A. He /she is confident B. He /she feels at ease C. He /she needs support D. He/she doesn't want to go to the swimming pool 2.2. How does your son/daughter get into the water? A. He /she jumps in right away B. He /she get into the water gradually C. He /she needs support D. He/she doesn't want to get into the water 2.3. How does he /she live the immersion? A. He /she enjoys it a lot B. He /she feels at ease during the immersion C. He /she doesn't like it D. He /she is scared about it 2.4. Does your child feel at ease when he /she is in water? A. Always B. Usually C. Sometimes D. Never	3. How do you get into the water? A. I jump in right away B. I get into the water gradually C. I don't want to get into the water 4. Can you go up the ladder? A. I can get up it in the deep end B. I can only get up it in the shallow end C. I can't get up the ladder 5. Can you float? A. I can float on my own B. I can float with the help of floats C. I can't float 6. Can you stay in the deep end without needing any equipment to help you? A. Yes, I can do that B. Only sometimes C. No, I can't do that 7. Can you put corks in the box? A. Yes, a lot and in the deep end B. Yes, but only in the shallow end C. I can't put any in 8. How many corks do you think you are able to put on the rope? A. A lot in the deep end B. A lot in the shallow end C. None 9. When you have a race with your friends in the deep end, what place do you usually come in? A. One of the first B. In the middle C. One of the last 10. Do your friends choose you to play in the water? A. They always ask me to play B. Sometimes they ask me to play C. They never let me play	88% 50% 90% 95% 64% 90% 80% 92%	94% 100% 94% 100% 87% 86% 60% 93% 93% 94% 47% 47% 47% 27% 87% 100%
Child (CHI)		Water competence (CHI)		
Teacher (TEA)	3.1. How is the relationship between your child and the teacher? A. Very positive B. Positive C. Negative D. Very Negative 3.2. Can you be satisfied about the swimming school offered by the teacher? A. Yes, completely B. Yes, partially C. Not at all D. No, I can't. 3.3. Has the teacher been able to create an empathic relationship with the children? A. Yes, completely B. Yes, partially C. Not at all D. No, he hasn't. 3.4. Do you think that the teaching organization has been effective? A. Always B. Usually C. Sometimes D. Never 3.5. Do you think that the teacher has promoted the relationship between peers? A. Yes, completely B. Yes, partially C. Not at all D. No, he doesn't.	98% 90% 96% 50% 92% 86% 90% 85% 43% 21%	Psychosocial aspects (TEA)	

Relationship with the teacher represents the **Core Category (98%)**. **General satisfaction (96%)** seems strongly dependent on it and it is supported by a good teaching organization.

The empathy created by the teacher with the children allows the development of the relationship with teacher.

The influence of the teacher on the social sphere that includes children and his or her relationship with the peers, is not perceived as fundamental.

The water competences in the child sphere are all related to the Core Category. In fact, in parents' opinion, a good relationship with the teacher let a confident entry into the water of the child, developing a good relationship with the swimming-pool environment and a good relationship with the water. The **immersion** is a positive experience only for the **64%** of the children.

Learning to swim is a more crucial aspect for the parents of the LI group. Positive answers to the question "Do you think that the swimming course has enabled your son /daughter to learn the swimming technique?" account for **71%**. From the parents' point of view, **well-being** created by the swimming school is crucial for the growth of the children (**67%**).

As shown in Figure 3, the main theme, emerged from the questionnaire vaulted to investigate parents' NL perception, is related to the **water entry of the child (95%)**, which represents the **Core Category**. Water entry requires to have confidence with the water, which is an essential aspect of swim learning. On the other hand, in Figure 3, **learning to swim** does not result to be a relevant aspect in the physical literacy sphere (**29%**), but rather the **well-being (80%)** of the child. As previously mentioned, getting into the water presupposes that the child is confident and has a good relationship with the water. The positive answers to the question "Does your child feel at ease when he/she/is in water?" in fact are related to the balance, to move into the fluid with the proper pushes and to the mastery of breathing [10]. These are crucial aspects required in order to learn the **immersion**, which represents another obvious theme for the parents of NL group with the **90%** of positive answers.

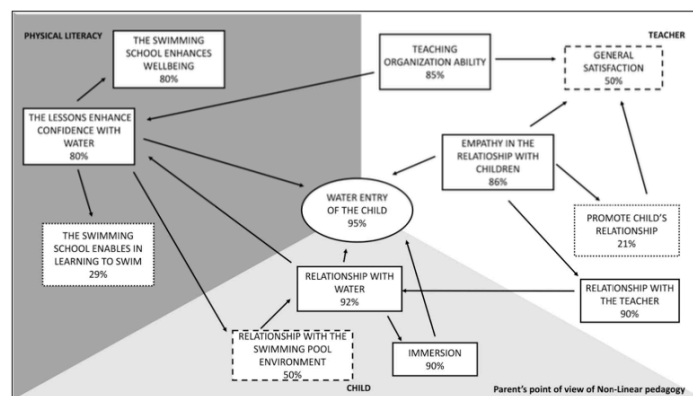


Figure 3. Diagram related to the perception of NL parents' group according to the results of the questionnaire administered.

According to the parents' point of view, having empathy with the children is important for the teacher in order to facilitate the water entry of the child. On the other hand, would not seem as crucial the ability of the teacher to promote the relationship between the peers.

Teaching organization allows to develop water confidence on the side of the child and indirectly influences the predisposition to entering the water.

General satisfaction of the child for parents of children in NL seems to be low (50%).

Establishing a good relationship with the swimming pool environment is perceived as a non-strict need in order to promote a relationship with the water and water confidence in an aquatic environment.

3.5. Specific Results Related to the Perception of the Aquatic Competence of the Children Post Intervention, Qualitative Analysis

In Figure 4, according to GT methodology, the analysis emerged from the pictorial scale to which the children were subjected is shown.

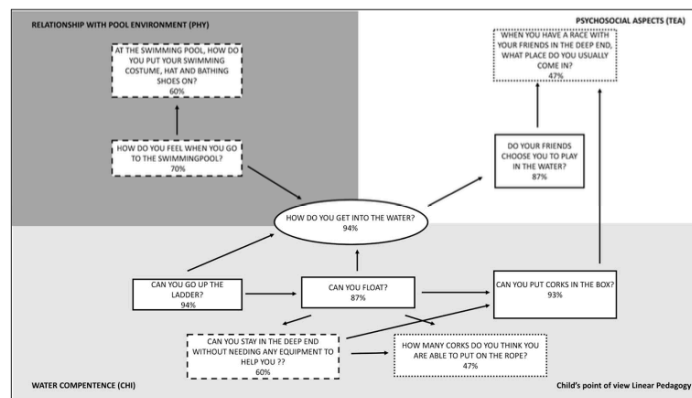


Figure 4. Diagram related to the perception of the children of the LI group according to the results of the pictorial scale indicating the percentage of positive responses.

Most of the children of the LI group **got into the water** happily (94%) by jumping into it or entering gradually. Getting into the water with confidence presupposes having a good relationship with it, as well as to be able to go up the ladder in order to exit both in high or shallow water and to float alone or with the help of corks. A good buoyancy allows the children to move easily into the fluid and to reach in, putting corks in a box quite easily both in high and low water.

The perception of a good buoyancy let the child to verify if he or she is able to stay in water without the help of corks, even if it turns out to be more difficult to put corks on the rope. Although there is good buoyancy and displacement in water, this unsureness could be motivated by an alteration of the spatial perception and to the difficulty in controlling the fine coordination in the aquatic environment, as well as to the pushing action of the legs in order to maintain buoyancy [8,10].

Getting into the water with confidence let the children feel at ease in an aquatic environment and promoted a **positive relationship with the swimming pool environment** (70%). The pool environment predisposes them to obtain a greater **autonomy on practical aspects** aimed at personal training such as putting on the swimming costume, the hat, and bathing shoes. This aspect is not completely achieved by all the children yet (60%). A comfortable environment let a better development of their own autonomy and self-efficacy [6]. Getting into the water with sureness grants an image and higher self-perception visible to the other children that predisposes them to **be chosen by their peers to play in the water** (87%). In fact, not all the children are chosen for play in the water by the others.

All the children of NL group (Figure 5) **get into the water** with ease (100%) by jumping into it or entering into it gradually, and all of them managed to exit using the ladder both

in high and shallow water. Most of them succeed in floating with and without the help of corks and this allows them to stay in water without invalidating difficulties and to put corks in the box both in high water and in low water. Putting corks on the rope is a quite difficult exercise for the NL group too. From a relationship point of view, the teacher's ability to create situations encourages the learning and allows the children to develop a sufficient self-esteem in order to promote the relationships within the group. This aspect allows all the children to be chosen by the peers to play in the aquatic environment (100%). The preparation of the activity by the teacher, according to a non-linear learning approach, let the children develop a greater autonomy, also in the training of the activity as putting the swimming costume, the hat and the bathing shoes by themselves. We can assume that they show **autonomy on practical aspects (93%)**. In fact, all of them are able to use the changing rooms independently. The self-efficacy sense allows them to feel at ease in the **swimming pool environment (80%)**.

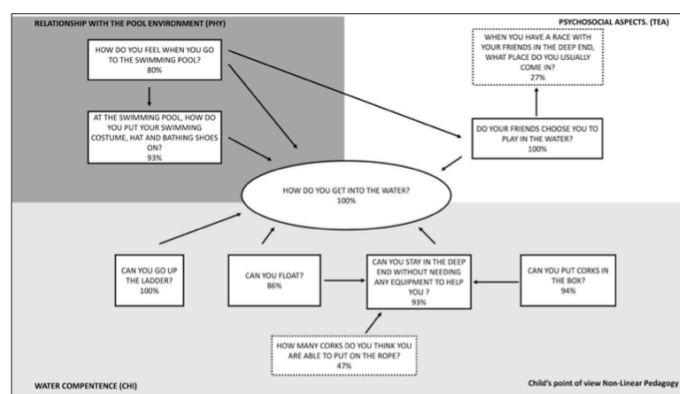


Figure 5. Diagram related to the perception of the children of the NL group according to the results of the pictorial scale indicating the percentage of positive responses.

4. Discussion

4.1. Parents' Preliminary Interview and GT Related to Parents' Perception

Analysis of the preliminary interview (Figure 6) showed that parents believe aquatic activity has a positive effect on the physical development of the child and that this is also related to the acquisition of good swimming competence and the learning of the technique. The analysis of the interviews also illustrated the importance of improving social and educative aspects. However, the re-processing of the questionnaire's data at the end of the activity, and after the division into the two groups, reveals two different scenarios.

Comparing parents' questionnaires of LI and NL groups, 8 out of 12 items presents better results in the LI group. Getting into the water of the child represents the positive core category (95%) of NL group, while "relationship with the teacher" is the main positive aspect in LI group (98%). From this comparison we can learn that the parent of NL group perceives the child at the center of the method, while in the LI group the teacher has a crucial role. As a result of this comparison, a different perception of the swimming school emerges.

In the NL approach great emphasis has given to the creation of a suitable environment in order to allow the development of the competence autonomously, through a three-valued approach as described in the Self Determination Theory (SDT) [25]. In SDT the aspects related to autonomy, competence and social context take shape in the Cognitive Evaluation Theory (CET) mini-theory, in which the intrinsic motivation arises from the satisfaction in

achieving results with their own abilities. In CET the perception of competence and the autonomy have a critical role in order to maintain intrinsic motivation, crucial in sport for children's participation in healthy behaviors across the life span [25–27].



Figure 6. Graphical representation about the fields of investigation of in the research work.

The NL group better perceived a positive relationship with water (92%) and immersion (90%) differently from LI group (80% and 64% respectively). The distinction in the perception of these two aspects can be due to the free exploration of the child who discover the environment respecting her/his own learning time, without forcing or anticipating the timing. Immersion is not lived as a constriction, so this method allows the children to a learn this fundamental in a less aggressive way [21].

However, the percentage of positive responses to the question “Do the lessons proposed allowed your son/daughter to have a greater confidence with water and swimming pool environment?” resulted to be higher in LI group (95%) than in the NL group (80%). The percentage of positive responses to the question “Do you think that the swimming course has enabled your son /daughter to learn the swimming technique”, is higher in the LI group (71%) than in the NL group (29%). The LI approach was oriented towards the motor learning, in which the acquisition of swimming technique resulted to be crucial through a systematic and gradual didactic progression. The role of the teacher in LI method was crucial because resulted to be a mediator of a technical learning in a more incisive and determinant way, through the organization of more dynamic and progressive lessons (90% vs. 85%). The level of general satisfaction investigated with the question “Can you be satisfied about the swimming school offered by the instructor?”, resulted to be lower in NL parents’ group than the LI group (50% and 96% respectively): the feedback regarding the immediate learning of swimming technique was related to the aquatic culture of the parents that in the preliminary interview confirmed to be source of satisfaction. These results presuppose the parents’ awareness regarding time and methodology necessary to acquire the fundamental motor skill to reach a proficiency barrier, useful for health and aquatic well-being [28]. Contrarily, this competence needs acquisition of specific knowledge that is not owned by the parents [29]. The impression that the parents had of LI group was that the lesson was organized in a more dynamic and challenging way, and that contributed to a better physical development because turned out to be clearer and more understandable by the observer. This methodology enforced the parent’s idea expressed in the preliminary interview and of the water activity. In LI methodology, social aspects were developed in a different situation than in the NL group because the different organization of the water

activity which was obtained with a teaching styles based on reciprocal observations [30]. In order to meet the priority of the parents, the child had to obtain good aquatic competences to ensure a safe future that prevents the risk of drowning [31,32]. In the literature is evident the relation between the parent's involvement and the child's behavior [33]. It is known that, some variables such as parental relationship may influence the well-being of the child [34]. In particular, aquatic experience of the child based on teacher centered pedagogy (LI), positively evaluated by the parents, could slow down the natural and optimal learning process [35]. This became particularly relevant when the teaching method presented excessive pressure to the learner [36].

4.2. Actual Motor Competence and Perceived Motor Competence of the Children

The children of LI group achieved a greater aquatic competence level than the NL group, according to the parents' expectations. According to literature, the method of how someone learns to swim is significant [37]. As shown in Table 2, the children of the LI group were better by about 7.3% in total results than children of the NL group. NL group instead achieved a greater homogeneity at the end of the swimming school than the LI group. We can assert that non-linear pedagogy, based on student centered pedagogy, contributed to reducing the intra-groups' competence gap. Data seems to agree to the aims of physical literacy: in the early to middle childhood period is particularly important to consider the individual learning path [36].

Regarding the perceived motor competence of the children, 7 out of 10 items presented better results in NL group. Children of LI and NL group are both able to achieve tasks such as putting on the swimming costume, the hat and the bathing shoes. The NL group perceived a greater positive mood (93% NL vs. 70% LI) and show off a greater autonomy in the changing rooms ("At the swimming pool, how do you put your swimming costume, hat and bathing shoes on?" 60% LI and 80% NL). The guided discovery and the free exploration of non-linear pedagogy let the child develop a greater self-efficacy because the child is allowed to reach the steps of the learning path within his/her own time [36]. This freedom allows him/her to acquire more confidence in his/her own competences, developing a greater autonomy even in tasks outside the swimming pool. The literature reported that the greater the perception of aquatic competence experienced by the participants, the greater their real aquatic competence. The teacher would be responsible for reinforcing a positive self-concept in children from three to six-years-old, to promote the development of perceived aquatic motor competence and help them to overcome fears which could compromise the development of certain actions [38,39]. 47% of the children in LI group and 27% of the children in NL group claim to be among the first places during races. We can assume that a student-centered pedagogy approach, as in NL group, didn't emphasize the competition in the activity proposed, while the opposite occurred in teacher-centered pedagogy, as in LI group ("When you have a race with your friends in the deep end, what place do you usually come in?" 47% LI and 27% NL).

This may depend on the emphasis given by the teacher (more oriented in a theory based on performance and less on the task), on the comparison with the peers, and on how much the teacher stimulated the aspects related to the competition. Furthermore, learning become difficult when the activity is compulsory and does not always respect the learning time of the individual [40,41].

Both the children of LI group (87%) and the children of NL group (100%) affirm to be frequently chosen by the peers during games ("Do your friends choose you to play in the water?"). Relationship with the peers resulted to be well structured both in LI and in NL group since the dynamics, given by a greater autonomy derived from a greater self-esteem, were directly managed by the peers, with a limited intervention of the teacher. In LI group, the direct approach of the teacher may have influenced some dynamics [36].

Respecting the timing of achieving the aquatic competences related to stay in water without the help of corks in NL group (93%) allowed the child to perceive better his/her self-efficacy than in the LI group (60%). Developing a perceived motor competence, based

on own actual capacity, allows a wellbeing status indispensable to build a physical literacy that includes affective, physical, cognitive and behavioral spheres [1].

4.3. Practical Applications

The aquatic motor culture of the parents can be modified through increasing their awareness about the differences and gaps between their perception and the children's perception. Moreover, the evaluation of the homogeneity of the group could be a useful tool in order to verify the effectiveness of the learning. In particular, the increasing of homogeneity in the NL group, as evidenced by the results related to the actual motor competence tests, can be recognized as an index of effectiveness of the learning. In the LI group, the decreasing of homogeneity in the results of the same tests, allowed the children to improve their aquatic technique evidencing the gap between the ones which are more able than others. This gap demotivates the most vulnerable children. This educational view of the swimming school could be motivated during the preliminary meeting with the parents.

We were able to see that the consideration that parents often have initially regarding the motor activity is strictly linked to the performance and the achievement of results; it is difficult for them to consider the psycho-physical and social well-being of their children. Relating the parents to the point of view of the children could enable them to modify their knowledge related to the aquatic motor culture, also taking into account the relational, emotional and psychological aspects, thus helping to raise independent and self-confident children. For this reason, the swimming school should have a more formative and educational vision, with the aim to lead the parent towards the awareness that the children and their needs must be placed at the center of learning in order to let them live a positive life with positive effects on their physical literacy and health [27].

5. Conclusions

In conclusion, both children and parents' group presented substantial differences related to the perception of the activity proposed.

We can affirm that NL approach was more appreciated by the children than the LI approach, while for the parents' group, LI method resulted to be more rewarding than the other because the initial expectation were satisfied. A preliminary interview let us verify the children's behaviors expected by the parents at the end of the course. It was a useful tool to expand the parents' knowledge related to their aquatic motor culture, highlighting the aspects related to autonomy, self-efficacy, achieved self-esteem and achievement of a healthy status in anatomical, physiological, psychological and sociological terms that can be conveyed by the swimming activity. We retained interesting to note that children obtained more evident progress in learning the swimming technique through the LI method, but there was a gap in what they perceived and what they achieved through the motor tests [42]. On the other hand, the children who learned with the NL method, developed an higher sense of awareness, self-efficacy (in changing rooms and in the relationship with the water) and self-esteem (in the relationship with the peers), which implies a greater assertion of soft skills [28]. The gap between the perceived competence and the actual competence depends on the lack of consciousness of their own abilities. This rare awareness is crucial in children which are between 4 and 8-years-old and this is due to the inability to abstract thoughts. With the growth and development of logical thinking, the child will be able to reduce the gap between perceived and actual motor competence [43].

This reflection is crucial for the didactic planning of the motor development of the child. It would be appropriate to emphasize how the educational view, differently from the utilitarian and sportive approach, could stimulate, referring to the physical literacy culture which include the individual need [44], the solidarity and attention to the most vulnerable children, improving their self-esteem through a better perception of motor competence.

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Article

Effects of Varied Practice Approach in Physical Education Teaching on Inhibitory Control and Reaction Time in Preadolescents

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Abstract: This study aimed to investigate the effects of nonlinear and linear varied practice compared to a constant linear practice on inhibitory control and reaction time, which are capacities that involve cognition in preadolescents. Eighty-three participants in the 8th grade participated in the study. They were assigned to two experimental groups (varied practice), taught using nonlinear pedagogy (NLP) and linear pedagogy (VLP), respectively, or one control group (constant practice), taught using linear pedagogy (CLP). All participants were tested for inhibitory control (congruent and incongruent conditions) and simple reaction time. Overall, varied practice (both linear and nonlinear) induced larger improvements than constant practice under both congruent ($p = 0.026$) and incongruent ($p = 0.013$) conditions of inhibitory control. Additionally, VLP provided greater improvements in inhibitory control (for the incongruent condition) than NLP and CLP. Although NLP and VLP may be preferable to CLP approaches for enhancing executive functions in preadolescents, VLP seems to be the most effective approach aimed to improve cognition within PE classes.

Keywords: school; linear didactics; nonlinear didactics; teaching styles; executive functions

1. Introduction

The World Health Organization recommends a specific daily dose of physical activity, from moderate to vigorous intensity, related to age and gender for health benefits [1]. Moreover, aerobic exercise is also considered as a “useful drug” to reduce age-related cognitive decline [2], as well as a preventative measure for cardiovascular and metabolic diseases [3].

In preadolescents, aerobic exercise affects both prefrontal executive control and hippocampal function [4] and has major effects on executive functions [5] involved in attention and concentration [6]. The prefrontal cortex, which is associated with executive functions, continues to undergo substantial changes during adolescence, as does the myelination of axons. This caused an increase in white matter and a decrease in grey matter, which led to a synaptic reorganization in 13–14 years old children [7].

As scientific literature has confirmed, the development of executive functions is also related to varied physical activity and to an adequate dose of exercise [8,9]. In this way, the literature has evidenced the necessity to consider both quantitative aspects (related to health) and qualitative aspects (related to motor control) of movement, as the same brain areas (e.g., prefrontal cortex) used to control the cognitive processes are activated during physical activity [10,11]. Although the brain reaches 95% of its development by the age of

6 [12], the prefrontal cortex takes about 20 years to achieve its ultimate growth [13]. As a consequence, inhibitory control can be particularly critical for preadolescents. This is due to the immature limbic system and prefrontal cortex and to a predominance of glutamatergic neurotransmission compared to gamma-aminobutyric acid neurotransmission, which remains under construction. This lack of inhibitory control might be responsible for immature and impulsive behavior and neurobehavioral excitement [14]. With an immature capacity to exert adequate cognitive control, preadolescents have difficulty managing executive functions, especially inhibition, which is connected to perceptual-motor executive skills [15,16].

In a specific motor context, executive functions, such as inhibitory control, are required with a simple reaction time, which is the capacity to respond quickly to a stimulus. It embodies the relationship between perception and motor action [17]. According to Vickers et al. [18], the average reaction time considerably decreases with practice in rapid hand reaction movements, due to a greater efficiency of nervous system information processing. Therefore, the higher the attention to the task and the inhibitory control, the quicker the response [19–21].

Reaction time depends on cognition and presents sensitive periods within preadolescence (from 7 to 12–13 years old) [22]. An immature stage of the brain with excess synapses, possibly due to a burst of proliferation, may decrease the performance and the frontal activation [23]. Two research lines can explain the pedagogies related to creating a transfer between motor activity and cognition. The first line refers to physical activity and cognitive commitment [24]. Integrating motor activity and cognitive tasks could improve cognitive development through interdisciplinary learning. Therefore, the child learns through motor activity, which is the means. Furthermore, voluntary control of the cognitive and motor behaviors based on transfer and interaction between the motor activity practiced in the gym and other intellectual activities could also improve, as executive functions played a key role. The second line is related to embodied cognition, which is founded on sensory-motor interaction with the environment, as brain development occurs due to the execution of the action and not to the cognition itself. This way, motor activity is the end; promoting the action, cognition develops [25,26].

Two different methodologies have been based on these two research lines in a pedagogical context. Linear and nonlinear pedagogy approaches are means for didactics which can facilitate the transfer between motor activity and cognition. In particular, repetition and variation represent the two variables of linear and nonlinear pedagogies, which favor the development of cognitive processes. The linear pedagogy is based on the cognitive (“central”) theory [27,28], and it is based on deliberate practice, founded on understanding and imitation of executive models. It traditionally supports learning by constant practice based on structuring, understanding, and repeating skills until they are acquired, focusing on a specific model of movement (education to the movement).

The nonlinear approach is based on the ecological-dynamic theory (peripheral). It stimulates the learner to find more personal solutions due to the continuous exploration of different and creative motor behaviors and the flexible usage of attention to solve environmental problems [29,30]. The nonlinear approach allows better creative thinking outcomes than the linear approach [31–33]. However, at the beginning of an educational process, linear pedagogy allows the learners to learn and structure the motor skills (giving models to understand, reproduce, and memorize), favoring the initial acquisition of the automatisms through repetition. It also allows more quick, economical, and non-dispersive use of attentive resources and cognitive efforts than does nonlinear learning [34]. Furthermore, the educator’s motivation in the linear pedagogy is essential and facilitates the acquisition of new skills and the use of selective attention [35].

Nevertheless, while linear and nonlinear approaches supposedly contrast each other, they are also comparable. To some extent, they are similar when the linear pedagogy approach is based on variation. In linear pedagogy, variations can relate to the coordinative difficulties defined by the characteristics of the task and the executive contrasts, which

allow for the exploration of all the specific feelings of the body and movement, through a kinesthetic differentiation, to learn a model of motor skill [36,37]. In nonlinear pedagogy, variations can relate to the functional difficulties occurring. The choice about a challenging task depends on the individual's skill level, on his/her perception of the situation, and on his/her personal strategies aimed to solve environmental problems. The discovery is indirectly guided by the teacher [36].

Contextual interference is another common aspect of the two approaches. It is a robust learning phenomenon that is the interaction between many combined motor abilities and situations based on varied or randomized practices that create motor disturbance situations through new, unknown, or different stimuli. These stimuli force the focus of attention on the main task to better perceive the sensations derived from it and obey a constant adaptation and alert. Therefore, they induce a decrease in the sensibility threshold and an increase in adaptation capacity, which leads to better use of the body in general and specifically, to the range of movement referred to in the model [38]. Interference and practice variation stimulate a continuous redefinition of motor programs and a kinesthetic perception of actions [39–41].

Nonetheless, other hallmarks, such as the learners' active involvement by reflection (obtained through reciprocal observations and self-check, during varied linear applications) and guided discovery (as in the application of nonlinear styles) can be retrieved in both pedagogical approaches as further action to advance cognitive functions [27,28,42].

Motor abilities can be acquired by focusing on the movement form (external appearance of actions) or content (inner motor processes stimulated through reflection based on questions, variation, and contextual interference). Reflective practices could be focused on the different modalities in which a motor task can be solved (nonlinear approach) or on the perception of kinesthetic sensations compared to executive results (varied linear approach) [43].

In a linear pedagogy approach, the attention is characterized by a monotasking experience focused on the main goal of learning. In a nonlinear approach, the research on perceptive learning showed that an embedded learning frequently changes operational conditions and induces the learner to continuous adaptation of the attention by multitasking experiences, promoting a "learning to learn" [44].

Even if the scientific literature showed that physical exercise in a dynamic and changing environmental context could improve attention skills and cognition more than in a static and predictable context [45], to the best of our knowledge, no study investigated the effects of a different varied and constant practice on executive functions and clinical reaction time.

The present study investigated the effects on inhibitory control and reaction time of a varied practice characterized by two different educational approaches (nonlinear and linear pedagogy) compared to a constant practice characterized by the prescriptive linear pedagogy approach. We hypothesized that variations would lead to inhibitory control and reaction time effects superior to those obtained through constant practice. Furthermore, variations in a linear approach should produce comparable cognitive benefits to a nonlinear approach. Linear approach variations are aimed at fostering better kinesthetic perception and movement-specific awareness, while nonlinear approach usually applies random practice under the dynamic system's ecological theory, which is aimed to favor an embodied cognition and a better general body awareness.

We can synthesize our research questions as follows: does a reflective approach based on movement content lead to different cognitive transfer effects than an approach based on the movement form? Does a varied linear approach based on a reflective practice determine the same cognitive transfer effects as a nonlinear approach?

2. Materials and Methods

Eighty-three students from two Italian secondary schools (8th grade) participated in the study (age 13.2 ± 0.3 years, height 1.60 ± 0.08 m, weight 48.4 ± 8.6 kg, body mass index 18.7 ± 2.2 m/kg²). The number of participants satisfies the sample size previously

calculated by the G*power software ($N = 66$). Due to practical reasons (intervention study performed during the curricular PE lessons), a quasi-experimental design was applied to establish cause-and-effect relationships between independent (teaching approach) and dependent (inhibitory control and reaction time) variables. Two public schools belonging to the same local area were involved in the study to prevent threats to research reliability, perhaps originating from differences in the participants' socioeconomic and cultural features. A control group was established among classes of one of the schools whose teachers previously declared to teach their students by a constant linear pedagogy (CLP) approach (one class designated). The experimental groups were designated in the other school to prevent the CLP teacher from any direct or indirect influence on his teaching approach by possibly watching the PE lessons led according to the experimental procedure. Therefore, two school classes acted as experimental groups and were taught with varied nonlinear pedagogy (NLP) and varied linear pedagogy (VLP), respectively, by two PE teachers with expertise in nonlinear and linear approaches collaborating with our research team (Table 1).

Table 1. Participant demographics.

	NLP (N = 27; 9 f, 18 m)	VLP (N = 28; 10 f, 18 m)	CLP (N = 28; 11 f, 17 m)
Age (yrs)	13.0 ± 0.0	13.0 ± 0.2	13.0 ± 0.2
Body mass (kg)	50.5 ± 8.6	49.4 ± 9.2	45.4 ± 7.3
Stature (cm)	161.3 ± 7.6	160.3 ± 10.0	159.9 ± 7.1
BMI (kg/m ²)	19.3 ± 2.4	19.1 ± 2.2	17.7 ± 1.8

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy; f: females; m: males; BMI: body mass index.

After being well informed about the study's potential risks and benefits, the participants and their parents or guardians provided written consent. They were allowed to withdraw from the study at any moment. The study was carried out under the Helsinki Declaration of 1975 and was approved by the Ethics Committee of the Università degli Studi di Milano.

2.1. Procedure

Before starting the training period, the participants were familiarized with the testing procedures, and inhibitory control and simple reaction time were assessed. In the subsequent 12 weeks, the participants attended the regular PE classes (1 h, twice a week), learning team sports basics and acro-sports as topics. Two PE specialist teachers with expertise in nonlinear and linear approaches taught NLP and VLP, while the PE school teacher using constant linear pedagogy taught CLP. Figure 1 and Table 2 depict the rationale of the study, participants' grouping, and the pedagogies' features. In addition, all interventions and examples of the teaching approaches are provided in the "training" section and Appendix A.

Table 2. Main features of the pedagogies used by the teachers.

	NLP	VLP	CLP
<i>Theory</i>	Ecological	Cognitive	Cognitive
<i>Procedure</i>	Mainly focused on the movement's content	Mainly focused on the movement's content	Mainly focused on the movement's form
<i>Pedagogical approach</i>	nonlinear	linear	linear
<i>Teaching styles</i>	Productive: guided discovery multitask	Reproductive: self-check, reciprocal style monotask	Reproductive: prescriptive monotask
<i>Task</i>	Distributed to several elements	Focused on sensory perception and on a specific element at once	No specific requirements, limited to the necessary model's observation
<i>Teacher's leading</i>	Indirect (learner-centered)	Direct/Indirect (teacher/learner-centered)	Direct (teacher-centered)
<i>Activities</i>	random	blocks	blocks
<i>Practice</i>	Non-constant	Non-constant	constant

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

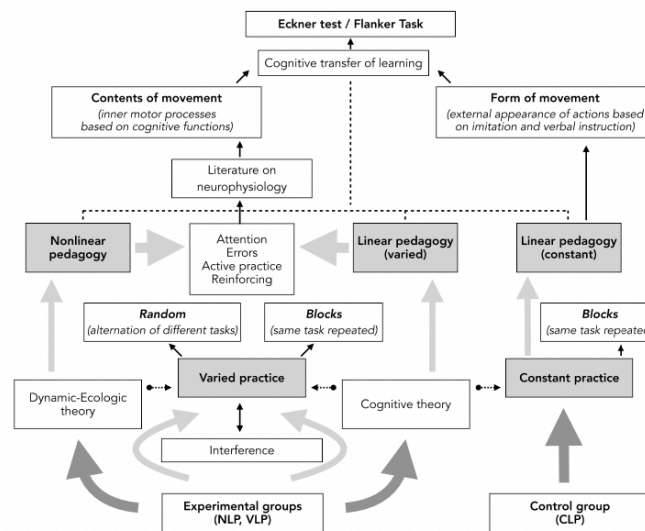


Figure 1. Study's rationale and procedure. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

To check that the teaching approaches corresponded to the expected ones, a random selection of PE lessons for each group was observed. PE lessons were video recorded and subsequently analyzed using the instrument for identifying the teaching styles (IFITS) [46]. The testing procedures were repeated at the end of the experimental period.

2.2. Testing Procedure

2.2.1. Inhibitory Control

A modified version of the flanker's task was used to measure the participants' selective attention and inhibition control [47]. First, participants had to detect the direction of the central arrow among the five that appeared on a computer screen as quickly and accurately as possible. Within two seconds, they had to press the A key on the keyboard when the target arrow was pointed to the left, and the L key when it was pointed to the right. They had to ignore the flanking arrows on each side, pointing towards the same or the opposite direction of the target one, and representing a congruent (left: <<<< or right: >>>>) or incongruent (left: >><< or right: <<>>) condition.

One hundred trials were presented (50 right and 50 left target arrows) with the same probability of congruent and incongruent conditions. For both congruent and incongruent conditions, the mean response time of the correct responses and response accuracy were considered for the analysis. The survey and experiments were implemented and presented online using the PsyToolkit platform [48,49].

2.2.2. Simple Reaction Time

Clinical reaction time was measured according to the methods of Eckner et al. [50] to assess the simple reaction time. Participants had to catch an apparatus composed of a wooden graduated stick (0 to 100 cm) having a weighted disk at its extremity as quickly as possible, as the examiner released it at random intervals. The participants sat with their dominant forearm on the table's edge. The examiner suspended the apparatus so that the weighted disk was aligned with the top of the participant's open hand. The distance the

apparatus fell (in centimeters) was recorded in eight consecutive trials. The mean distance was afterwards converted to time, in milliseconds, using the formula $d = 1/2 gt^2$. Then, the average of times was considered as clinical reaction time [50].

2.2.3. Video Analysis of the PE Lessons

For each experimental group, three PE lessons were randomly video recorded at the beginning, half, and end of the training period for a posteriori examination to verify the actual teaching approach adopted by a teacher during the classes. Specifically, the total time of activity, action time, resting time, reflection time, and duration of teaching styles were assessed three times and analyzed by three PE experts using the instrument for identifying the teaching styles (IFITS) [46]. The IFITS is a validated interval recording tool [51–53] that analyses what teaching style the teacher uses during the lesson and how long the teacher uses it [42]. Every 20 s, a rater identifies which teaching style the teacher uses and reports it on the IFITS coding sheet. The rater reports the total time (min) of each teaching style and calculates the percentage of each of them for the total activity time. A more detailed description of the instrument is provided by Curtner-Smith [46]. Intra- and inter-rater reliability were assessed using the intraclass correlation coefficient (ICC). The experts had been previously instructed and trained for six hours in collecting data and operating using coding instruments. The outcomes of the video analysis are provided in Table 3.

Table 3. Analysis of the teaching styles used by the teachers during the PE lessons and details of the students' activity.

	NLP min (%)	VLP min (%)	CLP min (%)	Intra-Rater Reliability (ICC)	Inter-Rater Reliability (ICC)
<i>Teaching Styles</i>					
Convergent guided discovery	16.3 ± 0.9 (30.5 ± 0.1)			0.99	0.84
Divergent guided discovery	33.3 ± 0.7 (62.4 ± 0.1)			0.99	0.80
Reciprocal		38.8 ± 2.5 (70.3 ± 0.2)		1.00	1.00
Individual-based choice	3.8 ± 0.1 (7.1 ± 0.2)	5.0 ± 0.3 (9.1 ± 0.1)	15.3 ± 0.7 (27.8 ± 0.3)	1.00	0.99
Self-check		11.3 ± 0.6 (20.6 ± 0.3)		0.99	0.87
Command			39.8 ± 2.4 (72.2 ± 0.3)	0.99	0.72
<i>Activity</i>					
Total time of activity	53.4 ± 2.8 (100)	55.2 ± 3.4 (100)	55.1 ± 3.2 (100)	0.99	0.81
Rest time	3.9 ± 0.3 (7.3 ± 0.1)	4.1 ± 0.3 (7.5 ± 0.1)	4.0 ± 0.2 (7.3 ± 0.1)	0.99	0.69
Time in action	36.5 ± 2.0 (68.3 ± 0.2) *	38.9 ± 2.6 (70.3 ± 0.4) *	46.5 ± 2.8 (84.4 ± 0.3)	0.99	0.99
Reflection time	13.0 ± 0.6 (24.4 ± 0.1) *	12.3 ± 0.9 (22.2 ± 0.3) *	4.6 ± 0.4 (8.3 ± 0.2)	0.99	1.00

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. For each teaching style and activity, the duration is shown as mean ± SD, with the corresponding percentage with respect to the total in brackets. Intra- and inter-rater reliability were calculated to assess the accuracy of the IFITS evaluation by video analysis. * $p < 0.05$ vs. CLP by post-hoc analysis with Bonferroni's correction after one-way ANOVA was performed between NLP, VLP, and CLP.

2.3. Training

Experimental and control groups participated in their regular PE classes as follows.

2.3.1. Nonlinear Pedagogy

The NLP group was taught using a nonlinear approach following the “divergent and convergent guided discovery style” by Mosston and Ashworth [42] based on the dynamic ecological theory of motor learning [54]. Several features composing the specific topic of each lesson were simultaneously selected and experienced based on practice variations and randomization. Pre-requirements and not specific motor models for acro-sport and team sports skills rotated every ten to fifteen minutes. The attention to the skills was indirect, multitasked, distributed, targeted, and adapted. Changes to the environment, task, and organism constraints were made rather than to the technical execution of a defined movement model [54]. Therefore, the students were indirectly encouraged to use a varied practice, including reasoning and knowledge of their self-adaptation ability, to address the managed affordances (Table 2).

2.3.2. Varied Linear Pedagogy

The VLP group was taught differently using a reproductive teaching approach, corresponding to the “self-check” and “reciprocal” styles of the spectrum of the teaching styles by Mosston and Ashworth [42]. It was based on cognitive theory principles with varied practice. Team sports basics and acro-sports were subdivided into tasks experienced in varied block practice (using a monotasking approach). After being instructed by the teacher through detailed instructions and direct demonstrations, the students were asked to reproduce and practice each task in pairs, switching the roles of executor and observer every ten minutes. The teacher controlled and provided support, suggestions, examples, analyses of errors, and stimuli to self-correct the performance through contrasting practice (requiring right and wrong actions). Again, attention was focused on the task-specific technical execution.

Therefore, the varied practice of VLP was mainly based on observation, comprehension, reproduction of reference models, and perception of one’s own body through contrasting situations that stimulate the kinesthetic sense (Table 2).

2.3.3. Constant Linear Pedagogy (Control Group)

The CLP group, acting as a control for the frequent use of the constant linear pedagogy in schools, underwent standard PE lessons promoting team and acro-sports. CLP was taught by the ordinary PE class teachers, who previously declared to follow a consistent linear pedagogy approach with their students. No requirements were made regarding his/her teaching approach, and no guidelines were given to him/her about how to address the learners’ attention. However, the lessons were video recorded and subsequently inspected to ensure, as the analysis confirmed, that the adopted teaching styles did not resemble VLP or NLP approaches (Table 3).

2.4. Statistical Analysis

Data are shown as mean $\pm$ standard deviations. A Shapiro–Wilk test checked the normal distribution. A one-way analysis of variance (ANOVA) was utilized to check the potential differences between practice/teaching approaches at the baseline (pre). No significant differences were observed between varied and constant practice (using the Student’s unpaired *t*-test) and between the three teaching approaches (using the analysis of variance—ANOVA) in the baseline (pre). To test whether the inhibitory control and simple reaction time were influenced by the practice/pedagogy used by the teachers during the PE period, we used two-factor ANOVA (i.e., time, practice/pedagogy) with repeated measurements of one factor (time) (two-way ANOVA RM). In case of significant interaction, Bonferroni’s correction was used post-hoc for pairwise comparisons. To better interpret and discuss the results, effect sizes (ESs, as Cohen’s *d* values) were calculated for the magnitude of the over-time changes (pre-post). The corresponding ES thresholds for *trivial*, *small*, *moderate*, and *large* effects were classified as <0.2 , 0.2 to 0.5, 0.5 to 0.8, and >0.8 , respectively. A further analysis was carried out to test potential differences subsequent to teaching practice and pedagogy. Therefore, we decided to proceed with the analysis by considering the changes after intervention with respect to before (delta, post-pre) as more directly representing the outcomes of the interventions. The Student’s unpaired *t* test was used to compare the deltas of varied and constant practice approaches. The one-way ANOVA, or the corresponding non-parametric test (Kruskal–Wallis), was used to compare the deltas of NLP, VLP, and CLP. In case of significance, a Tukey’s post hoc analysis (or Dunn’s multiple comparisons test, in case of non-parametric data) was used for pairwise comparisons. The level of significance was set at an α level < 0.05 . Statistical analysis was performed using GraphPad Prism version 7.00 for Windows (GraphPad Software, San Diego, CA, USA).

3. Results

Figure 2 shows mean $\pm$ SD of the response time of the congruent and incongruent condition of the flanker task before and after the 12 weeks of intervention (panels A and

C), with delta values (panels B and D), for varied and constant practice. The two-way ANOVA RM revealed a significant interaction (time $\times$ practice) for the congruent ($p = 0.026$; $F_{(2, 80)} = 5.08$) and incongruent condition ($p = 0.013$; $F_{(2, 80)} = 6.36$) of the flanker task. The main effect of time and group were not significant for both congruent ($p = 0.50$; $F_{(2, 80)} = 0.44$; $p = 0.99$; $F_{(2, 80)} < 1$) and incongruent condition ($p = 0.49$; $F_{(2, 80)} = 0.47$; $p = 0.60$; $F_{(2, 80)} = 0.26$). Post hoc analysis showed that varied practice improved in both congruent ($p = 0.027$, $d = 0.42$, *small*) and incongruent conditions ($p = 0.014$, $d = 0.37$, *small*). On the contrary, constant practice did not improve from pre to post in congruent ($p = 0.55$, $d = 0.17$, *trivial*) and incongruent conditions ($p = 0.45$, $d = 0.17$, *trivial*). Comparing the effects of varied and constant practice on inhibitory control, varied practice induced larger improvements (pre-post variations, deltas) than constant practice, in both congruent ($p = 0.026$) and incongruent ($p = 0.013$) conditions. Table 4 shows mean $\pm$ SD of the response accuracy of the congruent and incongruent conditions of the flanker task before and after the 12 weeks of intervention, together with delta values, p -values and Cohen's d values derived from the pairwise comparisons. For clinical reaction time (Figure 3), no significant interaction (time $\times$ practice) was revealed by the two-way ANOVA RM ($p = 0.55$; $F_{(2, 80)} = 0.34$), highlighting that the type of practice did not differently influence the clinical reaction time. Similarly, the main effect of time ($p = 0.09$; $F_{(2, 80)} = 2.78$) and group ($p = 0.169$; $F_{(2, 80)} = 1.92$) were not significant. Varied and constant practice did not improve from pre to post in the clinical reaction time ($p = 0.11$, $d = 0.21$, *small*; $p > 0.99$, $d = 0.13$, *trivial*, respectively). No significant difference was found in pre-post variations (deltas) of the clinical reaction time between varied and constant practice ($p = 0.53$).

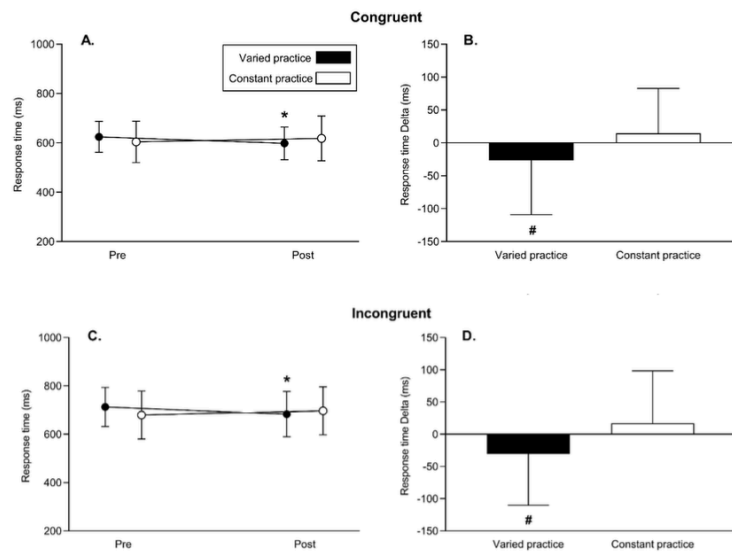


Figure 2. Inhibitory control evaluated by the flanker task, measured before and after 12 weeks of PE classes in varied and constant practice. Panels (A,B) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (C,D) show the response time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. Pre; # $p < 0.05$ vs. constant practice.

Table 4. Response accuracy (% of correct responses) in the congruent and incongruent condition of the flanker task in varied and constant practice.

	Time × Practice Interaction	Practice	Pre	Post	p-Value	Cohen's <i>d</i> ES	Delta (Post-Pre)
Congruent	$p = 0.012$; $F = 6.44$	Varied practice	87.7 ± 9.4	91.6 ± 9.1	0.146	0.41 (<i>small</i>)	3.8 ± 12.7 [#]
		Constant practice	91.4 ± 13.7	85.9 ± 15.0	0.138	0.40 (<i>small</i>)	−5.4 ± 20.5
Incongruent	$p < 0.001$; $F = 14.93$	Varied practice	85.9 ± 10.8	92.4 ± 7.8	0.035 *	0.60 (<i>medium</i>)	6.4 ± 13.6 ^{###}
		Constant practice	90.5 ± 15.4	81.6 ± 16.8	0.039 *	0.57 (<i>medium</i>)	−8.9 ± 24.8

F-values with *p*-values of the time × practice interaction derived using the two-way ANOVA RM. Values are mean ± SD. *p*-values (by Bonferroni's correction) and Cohen's *d* ES refer to the pre-post comparison. * $p < 0.05$; [#] $p < 0.05$, ^{###} $p < 0.001$ vs. constant practice.

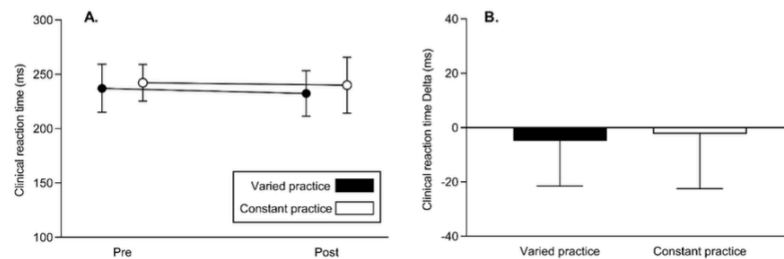
**Figure 3.** Simple reaction time evaluated using the clinical reaction time (Panel (A)) and pre-post variations (Panel (B); delta, post-pre) measured before and after 12 weeks of PE classes in varied and constant practice.

Figure 4A,C shows mean ± SD of the response time of the congruent and incongruent condition of the Flanker task before and after the 12 weeks of intervention, for each teaching approach. The two-way ANOVA RM revealed a significant interaction (time × practice) for the response time of the incongruent condition ($p = 0.018$; $F_{(2, 80)} = 4.19$) of the flanker task, whereas for the congruent condition, the interaction was not significant ($p = 0.066$; $F_{(2, 80)} = 2.80$). The main effects of time and group were not significant for both the congruent ($p = 0.14$; $F_{(2, 80)} = 2.20$; $p > 0.99$; $F_{(2, 80)} < 1$) and incongruent condition ($p = 0.07$; $F_{(2, 80)} = 3.32$; $p = 0.18$; $F_{(2, 80)} = 1.71$). When looking at the pairwise comparisons, teaching approach neither affected the response times of the congruent condition of the flanker task (NLP: $p = 0.07$, $d = 0.32$, *small*; VLP: $p = 0.67$, $d = 0.50$, *moderate*; CLP: $p > 0.99$, $d = 0.17$, *trivial*). Conversely, for the incongruent condition, only VLP improved from pre to post (NLP: $p = 0.11$, $d = 0.28$, *small*; VLP: $p = 0.007$, $d = 0.69$, *moderate*; CLP: $p = 0.22$, $d = 0.22$, *small*). Comparing the pre-post variations (deltas) in the response time for the flanker task between each teaching approach Figure 4B,D, no significant difference was found for the congruent condition ($p = 0.066$, $F_{(2, 80)} = 2.80$), whereas a significant difference was found for the incongruent condition for the flanker task ($p = 0.042$, $F_{(2, 80)} = 3.28$). Specifically, VLP differed significantly from CLP, confirming the positive effects of this teaching method ($p = 0.044$), whereas no significant differences were found between NLP and VLP ($p = 0.86$) or CLP ($p = 0.14$). Table 5 shows mean ± SD of the response accuracy of the congruent and incongruent condition for the flanker task before and after the 12 weeks of intervention, with delta values for each teaching approach, together with *p*-values and Cohen's *d* values, derived from the pairwise comparisons. The clinical reaction time for each teaching approach is presented in Figure 5. No significant interaction (time × practice) was revealed by the two-way ANOVA RM ($p = 0.79$; $F_{(2, 80)} = 0.23$), showing that the type of teaching approach did not differently influence the clinical reaction time. Similarly, the main effect of time ($p = 0.054$; $F_{(2, 80)} = 3.81$) and group ($p = 0.084$; $F_{(2, 80)} = 2.55$) were not significant.

Clinical reaction time did not improve from pre to post in NLP ($p = 0.27$, $d = 0.21$, *small*), VLP ($p = 0.10$, $d = 0.22$, *small*), and CLP ($p = 0.51$, $d = 0.13$, *trivial*). No significant difference was found in the pre-post variations (deltas) of the clinical reaction time between the three teaching approaches ($p = 0.26$; $F_{(2, 80)} = 1.77$).

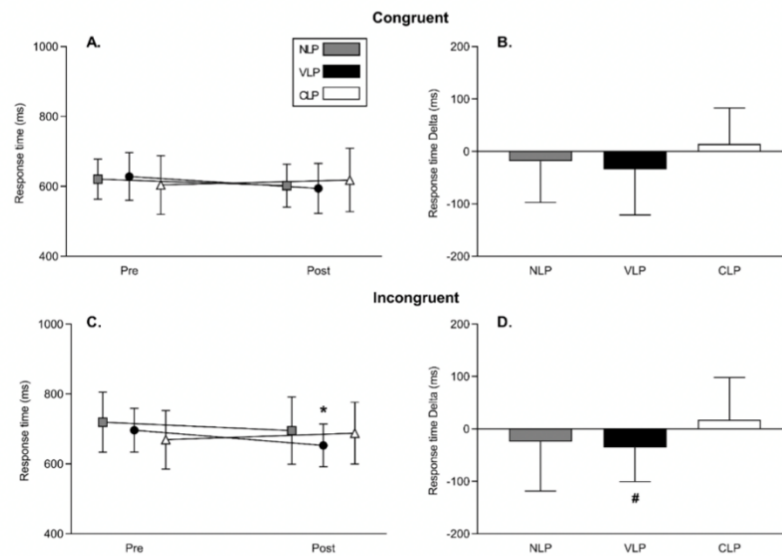


Figure 4. Inhibitory control as measured by the flanker task, measured before and after 12 weeks of PE classes using nonlinear pedagogy (NLP), varied linear pedagogy (VLP), and constant linear pedagogy (CLP). Panels (A,B) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (C,D) show the response time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. pre; # $p < 0.05$ vs. CLP.

Table 5. Response accuracy (% of correct responses) in the congruent and incongruent condition for the flanker task for NLP, VLP, and CLP.

	Time × Practice Interaction	Group	Pre	Post	p-Value	Cohen's <i>d</i> ES	Delta (Post-Pre)
Congruent	$p = 0.048$; $F = 3.09$	NLP	86.7 ± 8.8	90.4 ± 7.3	0.686	0.42 (<i>small</i>)	3.6 ± 11.5 #
		VLP	88.7 ± 10.1	92.8 ± 10.5	0.669	0.36 (<i>small</i>)	4.1 ± 14.0 #
		CLP	91.4 ± 13.7	85.9 ± 15.0	0.208	0.40 (<i>small</i>)	−5.4 ± 20.5
Incongruent	$p < 0.001$; $F = 7.74$	NLP	84.8 ± 9.3	89.7 ± 7.2	0.384	0.53 (<i>medium</i>)	4.9 ± 11.2 #
		VLP	87.1 ± 12.2	95.0 ± 7.6	0.049 *	0.66 (<i>medium</i>)	7.9 ± 15.7 ##
		CLP	90.5 ± 15.4	81.6 ± 16.8	0.018 *	0.58 (<i>medium</i>)	−8.9 ± 24.8

F-values with p -values of the time × practice interaction derived by the two-way ANOVA RM. Values are mean ± SD. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. p -values (by Bonferroni's correction and Cohen's d ES refer to the pre-post comparisons. * $p < 0.05$; # $p < 0.05$, ## $p < 0.01$ vs. CLP.

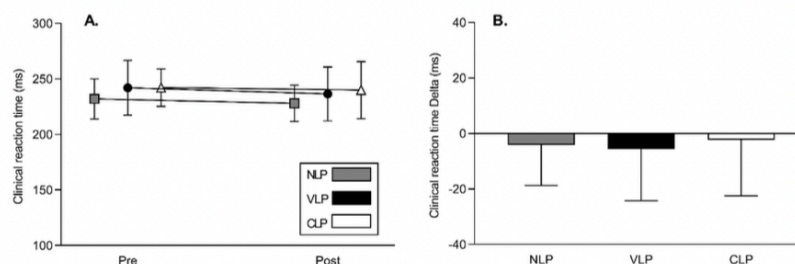


Figure 5. Simple reaction time evaluated using the clinical reaction time (Panel (A)) and pre-post variations (Panel (B)); delta, post-pre) measured before and after 12 weeks of PE classes for NLP, VLP, and CLP. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

4. Discussion

To investigate the role of type of practice and teaching approach on cognitive improvements related to PE, we tested inhibitory control and reaction time in preadolescents before and after a 12-weeks PE period taught using different teaching approaches (e.g., the varied practice of linear and nonlinear pedagogy and constant practice of linear pedagogy). Varied and constant practices induced different outcomes in the flanker task for inhibitory control and response time.

Two notable results were reported in this study. First, 12-weeks of PE based on varied practice induced superior benefits on inhibitory control (response time and accuracy of the flanker task) compared to constant practice. Second, VLP provided greater improvements in inhibitory control (response time of the incongruent condition of the flanker task), compared to NLP and CLP, which showed no significant changes.

Together, these results showed that varied practice, characterizing both NLP and VLP, showed greater improvements in inhibitory control than CLP. Contextual interference literature showed that diversification of the proposals allows a greater motor program elaboration [55] and a better stimulation of executive functions, with a better transfer capacity related to inhibition/self-regulation [56], as shown in our study.

Furthermore, reflection time was higher in NLP and VLP than in CLP (Table 3). Reflexive approaches of NLP and VLP stimulated metacognitive processes and greater awareness, which led to a better transfer in cognition [57].

On the other hand, the time in action in VLP and NLP was lower than in CLP. We can assume that the better results in inhibitory control in VLP are due to the quality of reflection and the cognitive processes activated through a reflexive practice, not for the quantity of practice [57,58].

Thus, varied practice within a nonlinear approach encourages new arrangements and increases the ability to adapt the learning outcomes to different situations [59]. This approach relates to an incorporate cognition view [25], in which brain activation [60] and cognition depend on action, and it is founded on perception-motor interaction [26]. Linear pedagogy assumptions of VLP are different from those of NLP and consider variations to solve errors through contrasting situations stimulating the kinesthetic sense. In fact, situational difficulties raise efforts to address the requests, favoring body awareness and enhancing transfer learning [61–63]. Teachers who use this approach encourage students to overcome difficulties by focusing their attention on relevant fundamentals for success and inhibiting their intuitive, quick, and less-reasoned responses [61].

Moreover, in contrast with a constant practice of the CLP protocol, approaches based on variations allow the learner to self-evaluate tasks and plan outcomes [64]. The fact that a varied practice of our protocol has improved performance in the flanker task supports

that pondering and reflecting, by stimulating proficiency and motor creativity, can speed up the learning process and improve executive functions, such as inhibition [65]. Therefore, frequent assessments and learning strategies based on context design and environmental changes are suggested to overcome the comfort zone (typical of constant practice), thus better promoting learning and supporting cognitive development.

The results of our study are based on the fact that qualitative, non-automatic demands activate the same regions of the brain that are used to control other cognitive aspects. The alert attentiveness created by variations and active involvement, based on the situations proposed, activate the reactivity and vigilance of the cortex [10,66]. We also tested whether a linear pedagogy induced more benefits than nonlinear pedagogy within the varied practice approach. The literature returns contrasting results, both supporting linear or nonlinear pedagogy [27,28,59]. The latter promotes motor learning through benefits from embedded attentiveness and concentration enhancement, integrating perception and action [67]. The NLP protocol (Table 2 and Appendix A) was based on the ecological dynamics theory [38]. Conversely, the monotasking approach of VLP had superior learning effects because of the prefrontal cortex activation, which reduced errors by focusing attentiveness on a single task [68]. Indeed, when looking at the pre-post comparisons, NLP showed a similar trend to VLP, albeit not significant ($p = 0.11$, $d = 0.28$, *small*), while CLP demonstrated a clear opposite trend (see the delta comparisons in Figure 4). These considerations may support the nonlinear pedagogy approach for cognitive improvement. However, VLP improved inhibitory control compared to NLP and CLP (Figure 4), which suggests that the VLP approach seems to be the most effective method for cognitive development in response to PE.

Referring to the results, active learning, based on students' autonomy and accurately guided by the teacher (VLP), is the most efficient approach in cognitive transfer situations for 12–13 years old children. Curiosity is the key element that determined a better attentiveness and executive functions in VLP approach. Curiosity refers to what the children think is useful to learn. In the same way that an activity that is too repetitive is not attractive, neither is a practice that is too confusing [69] or little related to specific goals.

The error plays a fundamental role in VLP. In fact, the brain can compare what has been predicted through the motor program and the outcome. Mental representation can be revised by referring to the prediction error [69]. When a prediction error occurs, it engenders surprise in the performer because of a violation of his expectations [70]. This would support specific psycho-emotional and cognitive processes indispensable for a learning transfer.

It is interesting to note that clinical reaction time was the only variable not affected by the different types of practice and teaching approaches. An explanation for the lack of improvement in the clinical reaction time can be related to the fact that this test assesses simple reaction time. There is evidence showing that physical activity is related to cognitive performance requiring a high level of attentional control in a complex reaction time task (i.e., incongruent conditions with flanking information) [71] more than in a simple reaction time task (such as clinical reaction time). Moreover, according to Posner [21], rapid hand reaction movement improvements would have been expected. It is plausible that more than 12 weeks of varied intervention training are necessary to integrate elaborative processes with neuromotor actions and then to discriminate improvements in this type of reaction time.

Some limitations should be acknowledged. The NLP approach was based on pre-requirements and not on specific motor models. Therefore, no motor tests were chosen for assessing acro-sports and team sport game competencies to compare the different pedagogies in which learning processes were centered. Further investigation on tasks, ages, sex, and expertise are needed to examine the effect of variability on transfer.

Practical Applications and Sustainability

Based on the results, PE teachers should provide lessons featuring learning based on reflection and varied practice. In particular, the learning should be characterized by: (a) the explanation of the usefulness and aims of the exercise; (b) the use of appropriate integrated methodology such as problem-solving, guided discovery, self-check, and reciprocal methods. These approaches can precede, be simultaneous with, or follow the practice and can be proposed before, during, or after the activity [72]. They could represent a concrete method to educate students to fit into present society.

The increasing complexity of modern society, the continuous innovations, and the consequent socio-cultural changes require quality teaching to guarantee the social utility of the learning [73,74]. The need for sustainable and quality teaching deals with the purpose highlighted by the 2030 Agenda of Sustainable Development Goals of the United Nations [75]. Among the various points covered, the document evidences the need to “ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles” [75].

Hence, in PE, sustainable and quality teaching should satisfy the broader need for the flexible adaptation to different contexts, promoting and developing social usefulness, and a lifetime of “good practices” pursuing long-term physical literacy [76]. In learning processes, teaching styles such as problem-solving, reciprocal, self-check, and inclusion methods could be helpful to promote engagement through active reflection and encouraging students to explore different and new solutions [77], gradually inducing them to interact with and fit into a constantly changing society.

5. Conclusions

The present study revealed that 12 weeks of PE based on varied practice improved inhibitory control more than did constant practice. The current findings also showed how a VLP better improved inhibitory control than either NLP or CLP. From a practical perspective, NLP and VLP may be preferable approaches for enhancing executive functions in preadolescents. However, VLP seems to be the most effective approach within PE classes aimed to improve cognition. Promoting PE lessons based on VLP might contribute to fostering targeted and individualized learning strategies, interdisciplinarity, metacognition (self-perception skills), and intrinsic motivation in school-age individuals.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the first author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Examples of contents and methods of activities by the pedagogies used.

NLP	VLP	CLP
No specific training on movement structure. Stimulation of functional aspects over constraints redirecting to the skills and abilities to be acquired.	Specific training addressing the movement's internal structure for learning sports basics.	Specific training addressing the movement's external structure for learning sports basics.
The teacher acts as a designer, organizes the affordances, and promotes actions by adequately setting the environmental constraints.	The teacher provides specific solutions to achieve success gradually and progressively through executive approximations, contrasts, and comparisons.	The teacher promotes segmented exercises of increasing difficulty that learners have to perform to manage the targeted skills properly.
The pedagogic fundamentals are perceiving, processing, and acting by selecting what and how to do a task.	Watching, judging, suggesting, and perceiving are the pedagogic fundamentals to master the movement, based on the internal processes of the central nervous system.	The primary educational feature is repeating the examples from the teacher many times to memorize and automatize the executions.
The teacher arranges varied environmental settings to arouse and produce adequate constraints to stimulate the functions connected to the specific targets. For example, a practice set to learn different positions and ways to manage balance relies on mats and benches. Object arrangements provide locomotory schema (climbing, passing, rolling, doing slalom, jumping) and object control (hitting, leading, throwing, catching). Eye patches or masks partially or completely limiting the vision is another example of an organismic constraint the teacher uses to force the learners' self-adaptations. Further constraints involving tasks are considered: assignments to the primary running skill are added (i.e., counting, summing, spelling a word, combining different movements, making associations as kicking with the right leg when an animal is named, or left when a plant name is called).	The teacher provides the executive model, organizes the learners in pairs, gives them individual self-evaluation sheets to detect the key points of the required techniques, the errors, and the necessary correction process. Kinesthetic information and the body's proprioception is favored by an experiential approach, based on executive contrasts and perceiving the experienced task's effectiveness. After practice, the teacher promotes group analyses and comments on each pair's work.	The teacher provides a simplified task of the target movement that the learners have to repeat until learning occurs. Then, the teacher offers frequent technical, general, and individualized feedback to guarantee the task's error solution and correct execution. Once most of the learners have had success, the next step is proposed, possessing increased difficulty. This process recurs until the target skill is properly achieved.

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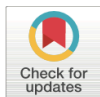
RESEARCH ARTICLE

The “thinking system” in a new school concept: A rhythmic teaching approach in physical education to develop creativity

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Abstract

System Thinking is an actual construct supported by several scientific evidence that offer a perspective on how phenomena relate. Rhythm methodology, teaching-learning, and enjoyment in physical education are the main system elements we hypothesize interacting closely to determine direct or mediated effects on motor creativity and rhythmic perceptive capacity. Seventy-six elementary and middle school students (8.9 ± 2.1 years) were randomly assigned to two groups: a) an intervention group that received a physical education lesson based on rhythmic methodology and b) a control group that received conventional lessons without specific rhythmic interventions. Participants were engaged in eight physical education lessons lasting one hour each for eight weeks. Tests and questionnaires were administered before and after the intervention to evaluate motor creativity, rhythmic perception capacity, self-perception and enjoyment. Two lessons were randomly analyzed to identify the teaching style and motor content (moderate and vigorous activity). The main results revealed direct effects on the intervention group's motor creativity ($p = 0.001$) and its rhythmic perception capacity ($p = 0.02$). Furthermore, enjoyment mediated the effects of the intervention on motor creativity ($p = 0.01$). Finally, the results have shown that self-perception does not mediate the effect of rhythmic intervention group on motor creativity and rhythmic perceptive capacity ($p > 0.05$). A rhythmic methodology proposed by specific multi-teaching styles can involve children and young people in an enjoyable activity with more moderate to vigorous physical activity.

Introduction

Thinking system and scholastic vision

A thinking system approach considers complexity as an intrinsic element of every change process, and this can be extended even to a formative path. This topic addresses a growing interest

related to the community of practice and the connection with other elements that can be functional in managing educational policy in real contexts. The thinking system approach encompasses emerging ideas and methods that promote the exploration of the most comprehensive framework, encouraging one to look at the bigger picture [1–3]. Thinking system can be traced back to three keywords: interrelation, as the connection between the elements of the system; multiple vision, as an approach to the issue that considers different viewpoints and perspectives (as qualitative and quantitative research with the use of mediators and moderators); boundaries, which delimited the interconnected elements and what is external to this system of interests. Literature has already shown a multi-faceted integrated system approach [4–6].

The framework proposed in a previous study is an example of how the formative system results from a complex relationship of many integrated domains, with different points of view and some elements found inside and outside the system of interest [6].

This way, to embrace an integrated and complex vision, the school is increasingly oriented towards a transdisciplinary approach that reflects the thinking system. The interrelation of several disciplines promotes a learning system based on a multiple vision, in which each discipline while maintaining its identity and characterizing elements, i.e., its boundaries, can also lead to other subjects enriching the learning process (i.e., music and physical education to improve on rhythm and motor creativity). Disciplines should not be presented as territories to be protected by defining rigid boundaries but as interpretive keys available for every possible use. Complex problems require different disciplinary viewpoints to dialogue with each other and to pay attention to the border and hinge zones between disciplines [7].

Rhythmic training and systemic view in scholastic context

The ability to sequence is very important in children's learning process. Rhythm-based practice in school settings enables children to acquire good temporal and rhythmic perception, which are essential for learning reading, writing, and language skills [8]. In a systemic view, the interrelation of music and physical education, through rhythmic perception and motor creativity improvement, can enforce the learning of reading, writing, and language skills in a multiple-vision concept [9–12]. In music, rhythm is the most important structural element. The music domain is organized into temporally structured sequences. It is composed of rhythmic structures that underlie an important organization of temporal successions [13]. Its metric organization is similar to linguistic syntax. Sensory-motor integration, motor control, and action planning can be analyzed through rhythmic syntax [14]. It is common to see how movement can be easily integrated within a musical environment through dancing, tapping, or nodding one's head to follow the rhythm. In more complex situations, two or more people interact during musical activity, playing and dancing together [15], and in social contexts, individuals act concurrently. Rhythm denotes a quality aspect of movement. More specifically, rhythmic movement in physical education considers a structured sequential form to utilize for favoring the acquisition of motor skills or expressions movements as manifestations of mental, social, and emotional responses [16].

Creativity in scholastic thinking system

Creativity must be considered a process incorporated in the cultural sphere of reference [17].

Creativity represents an act, an idea, that is produced in a particular field or that, starting from an existing field, generates a new one. Symbolic elements and specific notation systems mediate the knowledge expressed in the creative act. Each domain follows specific and rigid rules that limit its nature, modes of expression, and accessibility [18]. Creativity understood as a system must consider three components [18]:

1. The domain, made up of the specific symbolic rules and procedures that make up its structure. The domain referred to in this study consists of scholastic physical education and, with a finer concept analysis, in motor creativity.
2. The field, which refers to "the custodians" of the domain through which the possibility of including a new idea and didactic path is considered. The field in the school environment directly involves the teachers of the disciplines
3. People directly involved in the didactic-creative action (schoolchildren), and who, using the symbols of a domain, learn to express and identify a new pattern

Creativity in a specific domain has boundaries that determine what content can be included and what should be excluded. This way, transversality is a modality that can be used to grant new skills through the opening to accessible and related domains.

The efficacy of the choice of a related domain must be based on the criteria of clarity and simplicity of the new structure, its accessibility, and its possible recognizable presence in the main domain.

Transversal and transferable skills through the operational dimension of doing (as in the context of connection between rhythm and movement) can include new processes of critical thinking forming the basis of the creative domain of PE. These processes involved motricity and stimulated a new type of reflective and internalized learning that plays an essential role in self-construction, in which the student is an actor in his or her skills and knowledge acquisition [19].

Developing creativity in children is important to let them express themselves through the art of music and body expression. The student's proficiency in these multi-perspective skills can significantly impact their attitude, strategies' effectiveness, interpersonal interactions, and ability to gather and utilize feedback for adapting and improving actions across the considered domains [19]. In this regard, it becomes important that the context provides many possibilities for acquiring, memorizing, internalizing, and reproducing the stimuli of the different integrated domains. The school must develop integrated educational action to foster connections between relational domains and domains involving teachers who, in a transversal approach, follow a common path of intervention [19].

In this process, physical education and rhythm are the elements of the system that are considered within and beyond the interest in developing critical thinking processes. In particular, rhythm is conceived as a point in a system that can produce broad changes in motor creativity (leverage point) [20].

Added value by considering a comprehensive set of factors influencing motor creativity (understanding the complex drivers that can foster learning)

Factor 1: Teacher and motor creativity. Although the students occupy a central position in their learning process, the teacher also plays a crucial role in success. The teacher acts as an artist who has to shape his opera, referring to the context. He or she must create proper transdisciplinary pathways to achieve the transversal competencies. The teacher plays a key role in this complex system: through proper teaching practice, he/she can influence the students to learn and improve in a specific field. School autonomy [21] lets the teacher find strategies peculiar to the context to ensure their attainment of competencies at the end of the education cycle. The teacher is responsible for employing an integration teaching style related to the context [7]. Several studies highlight a relationship between the teacher's ability to vary the use of

different teaching styles and the involvement of cognitive, motivational, motor, and emotional aspects essential for maintaining an interest in developing creative-motor skills [22, 23].

Not surprisingly, an integration of several teaching styles allows for better creative thinking outcomes than a classical linear approach. Such an approach stimulates the student to find more personal solutions through continuous exploration of different and creative motor behaviors and flexible use of attention to solve environmental problems. Furthermore, through teaching styles that stimulate a maieutic and collaborative process, he or she can help the student develop his or her soft skills, which are indispensable for building the relationship with the teacher himself or herself and on which the outcome of the learning process depends [24, 25]. The teacher's task is to encourage motor activity within the educational process.

He or she can successfully achieve this goal through rhythm-based practice, offering age-appropriate qualitative and quantitative stimuli. Music, by its nature (temporal scansion and succession, structure, rhythm, sequencing), facilitates and makes the approach to motor practice almost spontaneous. A multi-teaching approach involving music, physical education, and creativity could enhance the learning process [26].

The relationship between music, movement, and creativity can be explained by the intervention of the primary motor cortex M1, which appears to mediate the potential for creative motor action associated with a pre-planned creative idea. The basis for a creative idea may form in brain areas associated with higher-order creative processes and then flow in part through M1 and be realized as a creative motor action [12].

In addition to the teacher's ability to establish relationships with his or her students, the ability to elicit enjoyment also plays a crucial role in the learning process [27].

Factor 2: Enjoyment and motor creativity. Enjoyment is a positive psychological effect that reflects happiness, pleasure, enthusiasm, liking, excitement, and fun [28]. In physical activity, enjoyment represents a positive attitude toward practice and is one of the most important aspects of motor development and sports participation [29].

Adequate levels of enjoyment and self-perception of physical fitness increase motivation, engagement, and participation in physical activity [30]. Pleasant and fun motor experiences in varied contexts are crucial for acquiring adequate bodily self-awareness in children and young people [31].

Factor 3: Motor creativity and self-perception. Assiduous participation in physical practice makes it possible to acquire and consolidate new motor patterns and increase motor competence in the long run. Children with a high level of motor competence are more likely to have an active lifestyle that positively influences physical and mental well-being [32]. Motor competence relies on its specific and highest manifestation in motor creativity, a perceptual ability that favors the development of new motor patterns aimed at solving problems or as body expression of ideas and emotions [33]. Motor creativity enables the production of motor movements and gestures to solve specific motor tasks or express emotion physically [33, 34].

Compared to motor competence, motor creativity develops more through exploratory teaching in an environment with well-adapted constraints, where kinesthetic variety is supported and where everyone is free to experiment through movement [34, 35]. Varied and positive kinesthetics and motor experiences improve the self-perception of children and young people by promoting the awareness of successfully acquiring different motor skills [36]. This capacity for self-perception is linked to the cognitive, motor, and social resources that the subject can mobilize in the different contexts in which he/she must produce motor skills [32]. The quality of experience provided by the teacher through effective teaching processes increases the positive self-perception capacity of young people [37, 38].

Research questions

Two research questions can be posed considering the following premises and the complexity of the thinking system approach in the school system. Does a skilled teacher using rhythm-based activities and appropriate challenges help students become more creative in their movements and better at recognizing rhythms? Also, how does the enjoyment of the activities, feeling competent, and age influence this learning process?

Materials and methods

Participants

Seventy-six elementary and middle school students were voluntarily recruited (from the 12th to the 19th of September 2022) for our study. Thirty-two students were in the second year of elementary school (2nd elementary school), twenty were in the fourth year of elementary school (4th elementary school), and twenty-two were in the third year of middle school (3rd middle school). Thirty-six participants were males, and forty participants were females. The students were divided into an experimental (section A) and a control group (section B), utilizing a class-randomized procedure. In this study, the experimental group underwent a rhythm-based intervention (RI), while the control group did not receive any rhythm-based intervention (NI). Participants' demographics are shown in Table 1. All participants and their parents were informed about the purpose and experimental protocol of the study. Parents or legal guardians provided written informed consent before the investigation. Following the Declaration of Helsinki, the study was approved by the Ethics Committee of the local University (approval number 18/22).

Measures

Rhythmic perceptive capacity. Mira Stambak test was employed to assess the rhythmic perceptive capacity. Stambak's test evaluates spatiotemporal structure by testing the rhythmic ability on multiple levels as a replication of temporal structures: the evaluator plays twenty rhythmic sequences in which each circle corresponds to a beat, and each space corresponds to silence. The child had to reproduce it respecting the beating and resting time; symbolization of spatial: the evaluator shows ten rhythmic structures one by one. After showing a structure for a few seconds, the examiner hid it from the participant. The participant had to memorize the structure and reproduce graphically each sequence; symbolization of temporal structures: the examiner reproduces the rhythmic structures by tapping. After listening, the participant had to write the sequence respecting circles and spaces. In each task, after two consecutive incorrect sequences, the test ends. A point is obtained when each successful structure is performed, and, in the end, the points obtained for each level are added [39]. Since 1951, Stambak's test has been used in different fields and research demonstrating its validity and reliability [6, 39, 40].

Motor creativity. Divergent Movement Ability (DMA) test was performed to investigate motor creativity in school-aged children. The DMA's validity and reliability were previously

Table 1. Participants' demographics.

Group	Male	Female	n	Age (years)	Height (m)	Weight (kg)	BMI (kg/m ²)
RI	21	22	43	9.02 ± 2.03	1.38 ± 0.16	35.00 ± 12.53	17.53 ± 2.87
NI	15	18	33	8.84 ± 2.22	1.38 ± 0.17	34.63 ± 13.3	17.60 ± 2.94

Data are mean ± SD; RI = Rhythm Intervention; NI = No-Rhythm Intervention. BMI = Body mass index.

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established [41]. No warm-up was done before performing the test. DMA measures the fluency and flexibility dimensions of creativity of three dimensions of movement skills: locomotor, for which an individual is asked to use the tools provided (e.g., two mattresses of different sizes, four cones arranged diagonally, a suspended rope, and a hoop supported by three cones) stimulating them to create as many movements as possible; stability, for which an individual is free to take on different figures (with their body parts) within an area with a 45.5 cm high bench placed in the middle; manipulation, for which an individual handles a ball (23 cm diameter) within an area (3 m × 4.5 m) delimited by cones (on three sides) and a wall (on the last side). Participants were tested on their ability to manipulate the ball. They were constantly motivated to provide as many solutions as possible. The examiner provided no feedback about their performance. Two-time trials were given for each skill with the following arrangements: 90 s for each trial with a 60-s resting period in between. Then, 120 s of rest were given between each dimension of fundamental movement skills. Each student was video recorded, and results were evaluated using video analysis. The score is composed of the number of solutions the student performs for each dimension of movement skills. A total score was assessed, summing score obtained in locomotor, stability, and manipulative areas [41].

Enjoyment. Enjoyment was recorded using the Italian version of the Physical Activity Enjoyment Scale (PACES) [42]. PACES questionnaire included 16 items classified into a 5-point bipolar Likert Scale (1 = totally disagree; 2 = disagree; 3 = not sure; 4 = agree; 5 = totally agree). A high score of positive items and a low score of negative items is related to high enjoyment. A total score can be calculated by reversing and adding the negative item score to the positive item score. The validity and reliability of the Italian version was investigated by Carraro and colleagues [42].

Self-perception. *Self-efficacy.* The Italian version of the Physical Self-Efficacy Scale (PSES) [43] was employed to evaluate Self-efficacy in year four elementary school students and in year three middle school students. PSES is structured into six items having a 1- to 4-point format scale. Students had to think about themselves when performing physical activity, and for each item, they had to choose the sentence that closely represents their performance. The total test is 1–24 scored. The higher the score, the higher the self-efficacy. The validity of the Italian version was investigated by Colella and colleagues [43].

Perceived motor competence. To measure the self-efficacy in the second-year elementary school students, the Pictorial Scale of Perceived Movement Skill Competence for Young Children (PMSC-2) [44] was used, instead of PSES. Indeed, according to previous studies [45, 46], self-efficacy, self-perception, perceived motor competence are related. PMSC-2 is structured with four graphical representations of the process of the movement. For each skill, students must think about how to perform the movement and choose images that best fit their thinking. The validity and reliability were established by Barnett and colleagues [44].

Video analysis. The video analysis was conducted through the System for Observing Fitness Instruction Time (SOFIT) [47] and through the Identifying the Teaching Styles (IFITS) [48]. Two out of eight lessons were randomly selected and recorded in both groups. The analysis was evaluated by some Physical Education (PE) experts using SOFIT to calculate the quantity of physical activity during each lesson and IFITS to evaluate the quality of physical activity in terms of the teaching style used. The data resulting from IFITS and SOFIT analysis were resumed and compared in the two groups as percentages. For both IFIT and SOFIT procedures, lessons were coded simultaneously by two independent observers using the same sampling pace. One of the two observers was considered the lead observer, and his data were considered for the analysis, while the second represented the reliability observer. Moreover, both observers performed the evaluation twice, distanced by a week.

Intra- and inter-rater reliability of SOFIT and IFITS was assessed using the following formula:

$$R\% = (n^{\circ} \text{ of agreement} / (n^{\circ} \text{ agreement} + n^{\circ} \text{ disagreement})) * 100.$$

The intra and inter-rater reliability was considered valid if the percent of agreement (R%) over-passed the 80% [41]. The same procedure of reliability was performed for the DMA valuation.

Procedures

The experimentation was led during PE classes, using the gym to perform the tests and the rhythmic and standard lessons, and the classrooms to complete the questionnaires. Anthropometric measures of height and weight were recorded to the nearest 0.1 cm with a standing stadiometer (Seca 217, Basel, Switzerland), and weight was measured to the nearest 0.1 Kg with a high-precision mechanical scale (Seca 877, Basel, Switzerland). Body mass index (BMI) was calculated as the ratio of body mass to height squared. Before testing the participants, a familiarization period was led. The two-week familiarization period included testing sessions for motor creativity and rhythmic perception. Both DMA and Mira Stambak's tests were repeated twice for reliability. The experimental tests and the questionnaires related to enjoyment and self-perception were performed after the familiarization period. The experimental session was carried out after the tests' performance and the completion of questionnaires. Eight rhythmic lessons, lasting one hour each, were conducted for the RI group, and eight no-rhythmic lessons were conducted for the NI group. The same PE teacher led the lessons. Two of eight lessons were recorded randomized, with a camera, and the videos were analyzed successively by a PE expert. At the end of the experimental period, tests and questionnaires were repeated. The experimental timeline is shown in Fig 1.

Content of the lessons

The lessons were led by an expert PE teacher who worked in elementary and middle school for four years and cooperated with the University of Milan in both groups, interacting with the school's music teacher. The 2nd elementary school RI group students attended lessons focused on rhythm perception using music, listening, discovering, and inventing rhythmic sequences with gym equipment. They worked individually, in pairs, and small groups. On the other hand, the 2nd elementary school NI group students attended lessons focused on topological and Euclidean space perception. They worked individually, in pairs, and in small groups as well. The 4th elementary and 3rd middle school RI group students attended lessons focused on rhythm in team sports such as basketball and handball, playing with music, following the rhythm of the music, or discovering rhythmic sequences in the technical skills. The 4th elementary and 3rd middle school NI groups attended lessons focused on team sports without taking care of rhythm perception but focusing on technical aspects, tactical strategies, and rules. Both groups worked individually, in pairs, and small groups. In the 2nd elementary school classes, we used most rhythmic cadence in 4/4 and few kid's songs as "Super simple songs for kids". In

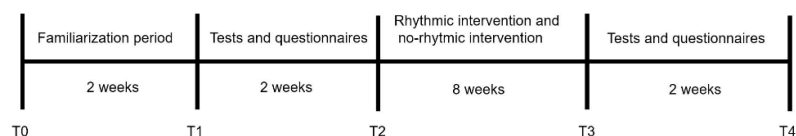


Fig 1. Overview of the experimental timeline.

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the 4th elementary and 3rd middle school classes we used rhythmic cadence in 4/4 as well and we choose songs from 100 (for technical aspects as bouncing, passing the ball, basketball and handball running shots) to a maximum of 140 bpm (for the musical fitness lessons only in the 3rd middle school). In 140 bpm songs we used a halved rhythm for marching or running on the spot, high knees, and toe touch, one movement every 2 quarters for squats and lunges.

Statistical analysis

The Shapiro-Wilk normality test and kurtosis/skewness analysis [49] were performed to assess the normal distribution of the data. Data are shown as mean $\pm$ standard deviation (SD). The reliability of DMA and Mira Stambak's tests was performed using the Intraclass Correlation Coefficient (ICC). The two-way Anova Time $\times$ Intervention (with repeated measures on time) was performed to investigate the intervention's effects on creativity and rhythmic perceptive capacity. The significance level was set at $\alpha = 0.05$ while the effect sizes were calculated as eta squared (η^2), using the small = 0.01, medium = 0.06, and large = 0.14 interpretation [50]. In addition, a multiple regression analysis was performed to obtain information about mediators and moderators. The mediation analysis was performed by Baron & Kenny's method following criteria for establishing mediation in which the independent variable (IV) is the intervention, the dependent variable (DV) is the main outcome, and the mediator is the variable controlling the IV-DV relationship. The mediation models were structured by placing intervention as IV, rhythmic perceptive capacity and creativity as DV, and enjoyment as a mediator variable (MedV) together with self-perception to provide a comprehensive measure of the effect of IV on DV. Pre-Post changes for each intervention group (RI and NI) was used as DV. A dummy variable was computed to distinguish RI and NI intervention. Specifically, the dummy variable took the value 1 for data corresponding to RI and 0 for data corresponding to NI.

Additionally, a moderator analysis was employed to investigate the role of BMI and age (as ModV) in influencing the effect of IV on DV. The total, direct, and indirect effects estimate was reported using β together with 95% Confidence Intervals (CI, lower: upper limits), while the significance level was set at $\alpha = 0.05$. The statistical analysis was performed using Jamovi (V. 1.6, R 4.0).

Results

All data met the normal distribution. All tests were found reliable (DMA Locomotor: ICC = 0.945; DMA Stability: ICC = 0.936; DMA Manipulative: ICC = 0.966; DMA total score: ICC = 0.974; Mira Stambak's test: ICC = 0.923). Table 2 shows descriptive statistics of each variable for RI And NI.

For rhythmic perceptive capacity, a significant Time $\times$ Intervention interaction was found ($p < 0.001$; $\eta^2 = 0.080$, medium). From Pre to Post, the RI group improved better than the NI group (Fig 2).

For creativity, a significant Time $\times$ Intervention interaction was found ($p = 0.001$; $\eta^2 = 0.041$, small). From Pre to Post, the RI group improved better than the NI group (Fig 3).

The first mediation analysis revealed that the intervention had a significant direct effect on rhythmic perceptive capacity ($\beta = 4.89$, CI = 1.83:7.96; $p = 0.002$). Conversely, no significant mediation by enjoyment was found (i.e., indirect effect; $\beta = 1.02$, CI = -0.92:2.96; $p = 0.30$).

Moreover, the second mediation analysis revealed that the intervention had no significant direct effect on creativity ($\beta = 4.09$, CI = -4.83:13.0; $p = 0.36$). However, enjoyment significantly mediated the effect of the intervention on creativity ($\beta = 7.63$, CI = 1.76:13.5; $p = 0.011$).

The third mediation analysis with self-perception variables showed that no significant mediation by PSES and PMC-2 was found (i.e., indirect effect; $\beta = -0.63$, CI = -1.67:0.39;

Table 2. Descriptive statistics for each intervention group (RI and NI).

	Variable	RI	NI
Pre	Locomotor (au)	41.9 + 7.2	41.7 + 5.3
	Stability (au)	31.8 + 6.5	30.7 + 5.2
	Manipulative (au)	36.4 + 8.7	35.4 + 7
	DMA total score (au)	110.1 + 19.8	107.8 + 13.6
	Mira Stambak (au)	32.8 + 5.2	30.4 + 6.5
	PACES (au)	69.2 + 10.7	70.7 + 9.8
	PMSC—2 (au)	31.4 + 4.7	33.6 + 5
	PSES (au)	18.7 + 3.1	19.1 + 3.8
Post	Locomotor (au)	47.7 + 5.5	41.7 + 4.9
	Stability (au)	37.4 + 9.5	31.2 + 8.9
	Manipulative (au)	44.6 + 7.4	36.2 + 7.6
	DMA total score (au)	128.7 + 18.2	109.1 + 13.8
	Mira Stambak (au)	37.7 + 1.5	29.5 + 4.9
	PACES (au)	75.4 + 4.9	65.2 + 8.3
	PMSC—2 (au)	35.6 + 3.5	31.1 + 4.4
	PSES (au)	20.4 + 3.3	17.5 + 4.2

Data are mean $\pm$ SD; RI = Rhythm Intervention; NI = No-Rhythm Intervention; DMA = divergent movement ability test; PACES = physical activity enjoyment scale; PMSC = perceived movement skill competence scale; PSES = physical self-efficacy scale.

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$p = 0.22$; $\beta = -0.99$, CI = $-4.18:2.20$; $p = 0.54$) on the effect of the intervention on rhythmic perceptive capacity. Similarly, the fourth mediation analysis with self-perception variables showed that no significant mediation by PSES and PMC-2 was found (i.e., indirect effect; $\beta = 2.12$, CI = $-1.48:5.73$; $p = 0.24$; $\beta = 4.42$, CI = $-2.80:11.16$; $p = 0.23$) on the effect of the intervention on creativity. The moderation analysis revealed a significant moderating impact of age on the relationship between intervention and rhythmic perceptive capacity ($\beta = -1.13$, CI = $-2.16:-0.09$; $p = 0.032$), but not of BMI ($\beta = -0.62$, CI = $-1.54:0.30$; $p = 0.18$). Regarding creativity, the moderation analysis revealed a non-significant moderating impact neither of age ($\beta = -2.60$, CI = $-5.44:0.24$; $p = 0.07$) nor of BMI ($\beta = -1.41$, CI = $-4.13:1.30$; $p = 0.30$) on intervention–creativity relationship. Fig 4 shows the structural model with the outcome of mediation and moderation analysis.

Both SOFIT and IFITS evaluations resulted reliable (SOFIT—Intra-rater reliability: $R\% = 84\%$, Inter-rater reliability: $R\% = 82\%$; IFITS—Intra-rater reliability: $R\% = 80\%$, Inter-rater reliability: $R\% = 81\%$). The qualitative and quantitative analysis of teaching styles are shown in Table 3.

IFITS's results per group and grade are shown in Table 4.

Discussion

This study in teaching physical education investigated the effect of a rhythmic approach on motor creativity and rhythmic perceptive capacity. The protocol of this research was based on system thinking and rhythms methodology. Teaching-learning and enjoyment in physical education are the main system elements that have been hypothesized to interact closely to determine direct or mediated effects on motor creativity and rhythmic perceptive capacity.

The main findings of the present study were that rhythmic teaching in physical education improved the rhythmic perceptive capacity and motor creativity in young students, which

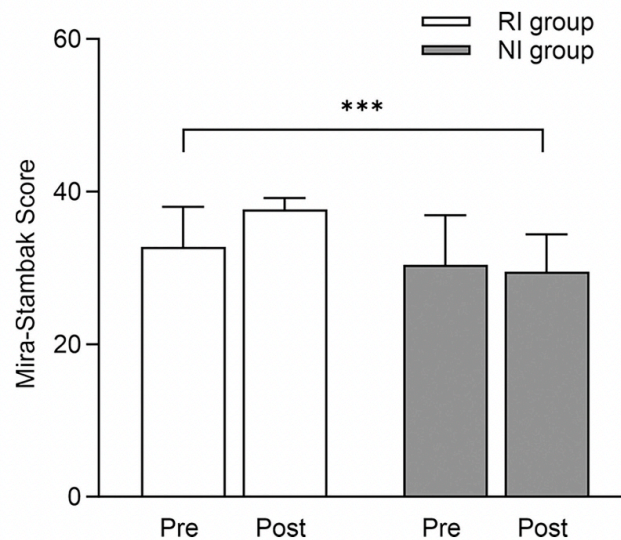


Fig 2. Effect of RI and NI on rhythmic perceptive capacity assessed by the Mira-Stambak score. Data are mean $\pm$ SD. *** $p < 0.001$ for time $\times$ intervention interaction. RI = Rhythmic Intervention. NI = No-Rhythmic Intervention.

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could be beneficial for other school subjects (i.e., music) [6]. Furthermore, such a teaching approach would increase the amount of moderate and vigorous physical activity during PE lessons in line with the recommendations and strategies for promoting motor practice established by the World Health Organization and other policy statements [16, 51].

The rhythmic approach let the RI group achieve more significant improvements in rhythmic perception than the NI group, which did not focus on this ability, as Mira Stambak's test results showed. The significant improvements in the RI group's rhythmic perception compared to the NI group may be attributed to the specific nature of the intervention [52].

Analyzing the results of the DMA, the RI group showed greater motor creativity than the NI group after the eight-week intervention, although the guided and divergent discovery styles were used more in the NI group. Our data appears to contradict existing literature [33], suggesting that a nonlinear approach is primarily conducive to developing motor creativity and creative thinking [22, 25]. Despite greater use of reproductive and linear styles, the rhythmic intervention has represented the leverage point in the context of system thinking through which it was possible to obtain substantial changes in motor creativity [6, 20].

Specific studies show how rhythm plays an important role in vital functions such as breathing and circulation and to guarantee coordinated actions in any movement [53].

Rhythm is the basis of all coordinated movement, and consequently, rhythm and movement can be efficiently combined to increase effectiveness in these interdependent domains [54].

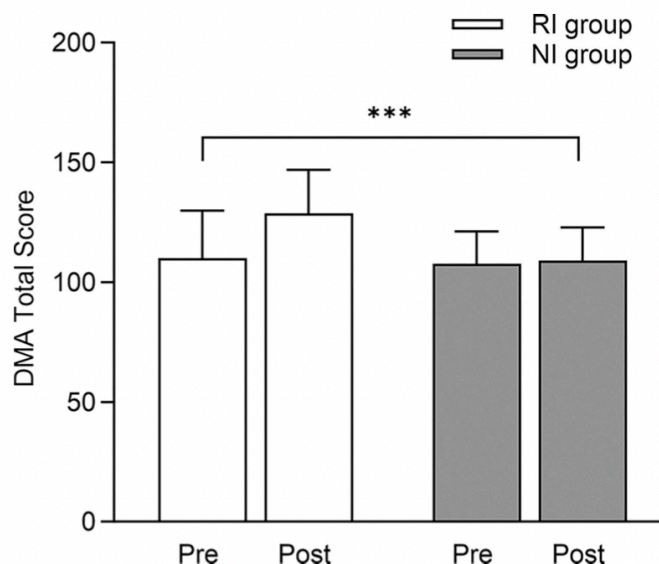


Fig 3. Effect of RI and NI on creativity assessed by the Divergent Movement Ability (DMA) total score. Data are mean $\pm$ SD. *** $p < 0.001$ for time $\times$ intervention interaction. RI = Rhythmic Intervention. NI = No-Rhythmic Intervention.

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The rhythmic abilities of children and young people encompass creative experiences, including imitation and interpretation, such as folk and social dances, singing rhythms, auditory rhythmic mental representations, and motor skill guidance [15].

By considering the relative importance of various factors in the context of system thinking, we hypothesized that utilizing an integrated multiple teaching style, which was indeed achieved in rhythmic physical education, could have led to a non-linear causal relationship with a more substantial outcome effect [22, 55].

Furthermore, greater use of practice and command styles in the RI group could allow learning better and consolidating rhythm and motor creativity skills. These observations are confirmed by the specific literature pointing out that internalization of a domain requires learning its rules and content through a large amount of information and frequency of stimuli obtainable through repeated exercises such as those guaranteed by practice and command styles [56] (Table 4). Conversely, management was less employed in the RI group compared with the NI group in every grade. This may be due to the rhythmic approach and styles that require less organizational management than a productive approach [57]. Analysis of the quantitative aspects (Table 3) of the SOFIT data showed that although the duration and motor content were similar in both groups, the RI group performed more MVPA% (Moderate to Vigorous Physical Activity%). This confirms how even this quantitative factor stimulated by the rhythmic proposition, probably due to the fast-paced nature that a rhythmic approach may require, may have contributed to a higher chance of exercising and assimilating the domain [16].

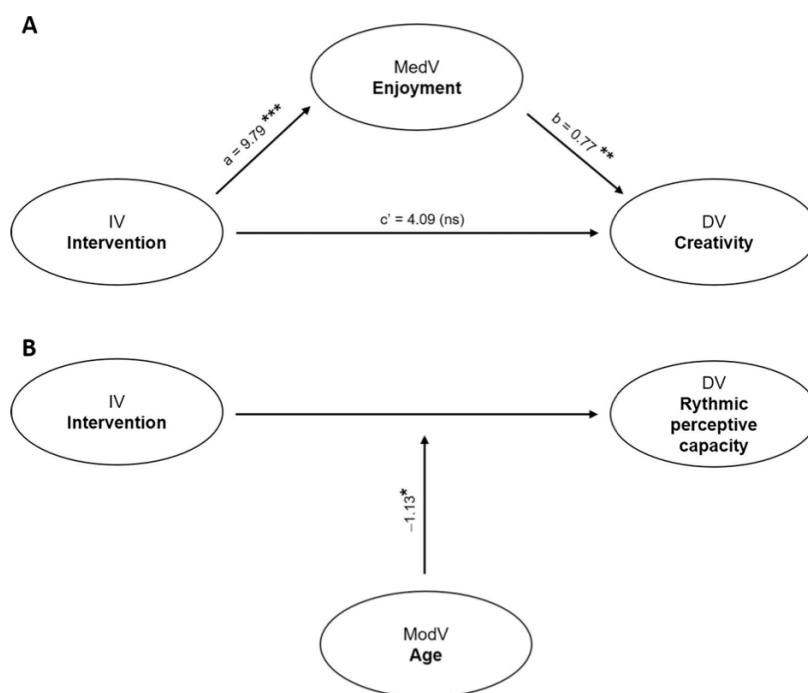


Fig 4. Panel A: Mediation model explaining the effect of intervention on creativity mediated by enjoyment. Panel B: Moderator model demonstrating age's impact on the effect of the intervention on rhythmic perceptive capacity. IV: independent variable; MedV: mediation variable; ModV: moderator variable; DV: dependent variable; a: effect of IV on MedV; b: effect of MedV on DV; c': direct effect of IV on DV controlling for MedV. ** $p < 0.01$; *** $p < 0.001$; ns: non-significant.

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Table 3. SOFIT results for RI e NI groups and for grades.

Group	Grades	Duration (min)	% MVPA	% MC	% PROM
RI	2 nd elementary school	57.5 ± 2.1	40.0 ± 0.2	47.7 ± 4.8	37.5 ± 3.7
NI	2 nd elementary school	59.0 ± 11.3	29.4 ± 11.5	53.7 ± 10.8	23.7 ± 19.5
RI	4 th elementary school	51.3 ± 2.4	62.3 ± 3.0	56.3 ± 3.7	32.7 ± 1.4
NI	4 th elementary school	47.2 ± 3.1	44.9 ± 0.6	54.3 ± 3.5	0.0 ± 0.0
RI	3 rd middle school	38.8 ± 4.5	62.8 ± 20.1	74.5 ± 18.1	38.6 ± 49.8
NI	3 rd middle school	37.0 ± 11.3	25.5 ± 3.6	65.6 ± 4.8	0.0 ± 0.0
RI mean		49.2 ± 8.9	55.0 ± 14.8	59.5 ± 14.9	25.7 ± 29.4
NI mean		47.7 ± 12.3	33.3 ± 10.6	57.9 ± 8.1	7.9 ± 15.0

RI = rhythmic intervention; NI = No-rhythmic intervention; MVPA = moderate to vigorous physical activity; MC = motor content; PROM = physical activity promotion.

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Table 4. IFITS's results per group and grade.

Style Duration (%)	2 nd elementary school		4 th elementary school		3 rd middle school		Group mean	
	RI	NI	RI	NI	RI	NI	RI	NI
Command	14.6 ± 10.7	4.6 ± 1.9	30.5 ± 8.4	23.5 ± 8.2	8.0 ± 0.7	10.4 ± 14.7	17.7 ± 12	12.8 ± 11.5
Practice	16.4 ± 23.2	0.0 ± 0.0	39.9 ± 2.2	31.0 ± 7.2	47.0 ± 9.6	28.4 ± 2.5	34.4 ± 18.2	19.8 ± 15.7
Reciprocal	10.5 ± 14.9	6.8 ± 2.2	0.9 ± 1.3	0.0 ± 0.0	6.5 ± 9.3	4.8 ± 6.7	6.0 ± 9.0	3.9 ± 4.5
Self-Check	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	4.8 ± 6.7	0.0 ± 0.0	1.6 ± 3.9
Inclusion	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Guided Discovery	0.0 ± 0.0	12.5 ± 17.7	19.8 ± 6.7	20.7 ± 2.4	10.7 ± 15.2	5.6 ± 7.9	10.2 ± 11.6	12.9 ± 11.1
Divergent	4.3 ± 6.1	15.8 ± 13.9	2.5 ± 3.6	0.0 ± 0.0	0.0 ± 0.0	2.4 ± 3.4	2.3 ± 3.7	6.0 ± 9.9
Go Beyond	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Management	54.2 ± 8.6	60.3 ± 0.3	6.6 ± 1.3	24.8 ± 13	27.7 ± 14.1	43.8 ± 12.5	29.5 ± 22.6	43 ± 17.8

RI = Rhythm Intervention; NI = No-Rhythm Intervention.

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Furthermore, this data is not of secondary importance when also considering the effect of rhythmic teaching in increasing active practice (moderate and intense) during lessons with the consequent health benefits reported in the literature [16, 51, 58].

The reciprocal style primarily used in the RI group allows a continuous relationship and feedback between students. Furthermore, the student acting as an observer learns to analyze and correct his partner's mistakes and stimulates critical thinking, which is essential in developing motor creativity. The interaction between the students determines the solicitation of social skills, making the proposals more exciting and pleasant [7, 57].

The mediation analysis revealed that enjoyment was the only mediator that had a significant impact on the relationship between motor creativity and intervention. None of the other mediators under consideration had any impact on either the relationship between intervention and motor creativity or the relationship between intervention and rhythmic perception. The observed results can be primarily attributed to the direct impact of the rhythmic intervention, particularly when combined with a specific multi-teaching styles methodology [7, 15, 22].

Durable sounds and sensations, such as those of the lullaby that mothers sing to children to make them fall asleep, determine sweet and pleasant rhythmic sensations, and reinforce the bond with their mother [59]. This example illustrates how appropriate rhythmic activities in physical education, such as songs and simple dances, can create enjoyable and satisfying experiences, thereby stimulating the desire for learning and fun in children and young people [16, 60].

Furthermore, listening to pleasant music integrated with movement helps stimulate divergent thinking, a key element of creativity [61]. However, it was impossible to consider this "music component" through the IFITS analysis because it was not contemplated as a possible type of divergent style.

By looking at the data from the perspective of the key concepts of system thinking, some effects could be delayed and made observable over a longer period [62]. This effect could occur when trying to change a complex system. Behavioral and interaction fluctuations (characterizing complex systems) may hide more possible connections between the variables and the mediators considered, making it take longer to see other possible effects [62].

Although the literature recognizes possible relationships between positive self-perception, enjoyment, and competence not only in physical education but in numerous fields of school learning [63], we believe that the construction of a body image capable of mediating the relationship between rhythm and motor creativity, being the product of variables involving

multiple domains in a transversal form, could require a longer intervention time to be assimilated determining a mediation effect [64, 65].

The moderation analysis of intervention-rhythmic perception and age relationships shows a significant effect, highlighting how age and previous experience can affect rhythmic perception. Regarding motor creativity, weight appears to condition this domain. Students with a higher weight are generally older than those with a lower weight. Therefore, the age of practice could also condition motor creativity, and their expertise confirmed the relationship between age and DMA [6].

From the emerging results of this study, a multilevel model [4] based on system thinking can be characterized by three systems that, through a closed chain of causal connections, determine the effectiveness of the systemic approach. These three systems are:

- The exosystem, which is made up of the most distant level from the subjects towards whom the experimentation is directed. This system is represented by legislation, policies, and governance systems that, in a scholastic context, represent the national guidelines (ministerial guidelines) [7] that, by the support of empirical and scientific evidence, have acknowledged the important role that rhythmic education, creativity and the transversal/transdisciplinary nature of the proposals, play in the education of children and young people;
- the mesosystem, which represents an intermediate level, constituted by the cultural institutional reality of the school, made up of families, school leaders, teaching subjects, and other stakeholders. The efficacy of this intermediate level is characterized by an environment that permits the implementation of transversal educational experiments, avoiding being excessively repressive and conservative of boundaries of each discipline;
- the endosystem, which is made up of the environment in closest contact with the school children, of related teaching domain (music and physical education school subject) and its related fields (positive relationship and interaction between teachers transversally involved) [4].

This way, particularly relevant, is the teachers who direct the students' interest, support them, and consider the students' abilities by creating the right balance between "challenging proposals and execution skills" to promote pleasure and interest and avoid frustration by proposing tasks that are inadequate for them.

The mediation analysis revealed that enjoyment did not mediate the effect of the intervention on rhythmic perceptive capacity, suggesting that other variables (not assessed in the present study, such as attention, focus, and cognitive engagement) may play a mediating role in the relationship between the intervention and rhythmic perceptive capacity. This finding agrees with Vazou and colleagues [16].

Regarding creativity, the mediation analysis revealed that enjoyment significantly mediated the effect of the intervention on creativity. This suggests that the positive effect of the rhythm-based intervention on creativity was partially mediated by the enjoyment experienced by the students during the intervention. These findings are consistent with previous research highlighting the importance of enjoyment and its positive effect in promoting creativity [66, 67]. The intervention's rhythmic activities and music-based elements may have elicited positive emotions and a sense of enjoyment, enhancing the students' creative thinking and expression. Overall, this emphasizes the teacher's role in conducting physical education programs (like rhythmic-based interventions) utilizing strategies promoting enjoyment [68].

The moderation analysis showed that age had a significant moderating impact on the relationship between the intervention and rhythmic perceptive capacity, indicating that the effect of the intervention on rhythmic perceptive capacity varied depending on the age of the

students. This finding suggests that younger students may benefit more from rhythm-based interventions to improve their rhythmic perceptive abilities. However, no significant moderating impact of BMI was found, indicating that BMI did not influence the effectiveness of the intervention on rhythmic perceptive capacity. These findings are consistent with a recent study showing age-related differences in rhythm perception [6]. Younger students' developmental stage and cognitive abilities may make them more receptive to rhythm-based activities and interventions.

Regarding creativity, the moderation analysis revealed a non-significant moderating impact of age and BMI on the intervention-creativity relationship. This indicates that neither age nor BMI significantly moderated the intervention's and creativity's relationship. These findings suggest that the rhythm-based intervention positively affected creativity across different age groups and BMI categories. This aligns with research showing the universal benefits of music and movement interventions on creativity in diverse populations [69].

Limitations of this study

There is a paucity of literature on the relationships between rhythmic-motor teaching, motor creativity, teaching styles, children's motor engagement during the lessons, enjoyment, and self-perception. It is therefore essential to recognize that the scholastic thinking system could represent the foundation of future studies to provide objective data on the effectiveness of the framework of the ecological model in physical education [6].

Data of our model include a small number of participants for a clear analysis that considers differences in age, gender, and other mediators and moderators considered self-perception or weight. In particular, as for self-perception, we used two types of questionnaires to measure self-efficacy and perceived motor competence (due to the lack of a single validated instrument capable of evaluating this component in children in the first elementary classes and the young in the last years of middle school), the small number further reduce the representativeness of the outcomes.

Practical applications

System thinking allowed us to highlight two fundamental points of rhythmic teaching (leverage and resistance points) to improve motor creativity. Thanks to the particularity of these domains, the transversality between physical education and rhythmic-musical education is a leverage point that can lead to effective results. A little skilled teacher and an unfavorable environmental reality could represent a resistance point. To avoid this, a competent teacher should have the ability to create, through a varied and engaging rhythmic multi-teaching approach, adequate relationships and enjoyment with the students to whom he relates (proposals adequate to the age and subjects' characteristics, suiting what they can and know to do). Without these conditions, the resistance points compromise the project's possibility. An environmental reality (educational managers, music teachers, parents, educational and ministerial programs) should be based, above all, on the possibility of encouraging overcoming the educational boundaries of the subjects involved in the project (possibility of blending physical education with other subjects).

Conclusions

This study emphasizes the relationship between rhythms and motor creativity and the importance of enjoyment in engaging during these lessons' typology. The results of the present study, which also considered teaching styles and the type of motor practice, provide new insights for school teaching and support system thinking as a way to understand how all

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Article

Relationship Between Multi-Teaching Styles and Didactics Effectiveness on Rugby Instructors and Minirugby Players

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Abstract: Background/Objectives: The concept of educational systems thinking shows the rugby educational system as a network of multiple interactive and interconnected elements. However, the frameworks presented in the literature for developing sports practice through an educational vision and multisport engagement do not always have direct transferability to instructors' training courses. The study aims to evaluate the correlation between rugby instructors' methodological and didactical competencies and compare them with children's motor competence and psychological aspects. Methods: Two hundred twenty children (9.6 ± 1.1 years) and 50 instructors (39.0 ± 13.6 years) were enrolled. Instructors' competencies were investigated during the internship through evaluation sheets, questionnaires, and video analysis. Children's motor competence and psychological aspects were investigated through motor tests, questionnaires, and video analysis. Results: The correlation between methodological competencies and didactical-communicative competencies showed a positive significance, especially regarding production styles. Motor competence and play skills in children showed poor results. The group of instructors with more methodological competencies (a greater number of teaching styles used) showed a strong correlation between motor competence and psychological aspects. Conclusions: For successful teaching, knowledge of specific technical skills is not enough, and it is important to consider all the factors (in particular, the teaching-communicative and methodological skills) that contribute most to instructors' skills.

Keywords: teaching styles; sport education; competent instructor; didactical success; instructor's empathy; systems thinking

1. Introduction

The concept of rugby's educational system can be defined as a complex dynamic system that includes, from a systems thinking perspective, multiple interactive, interdependent, and interconnected elements [1–3]. The dynamic concept, in particular, refers to a current behavior understood in terms of deviations from past behavior that, concerning current regulations [4], envisions a view of sports not only in performance terms but primarily in educational terms [5]. From this perspective, verifying the formative trajectories that make the different professional skills of the instructors interact with the motor and psychological evolution of the children attending the minirugby courses allows us to clarify and define the values and meanings that the Italian Rugby Federation attributes to youth sports practice. This “educational diagnosis” of the teaching reality, based on “Systems

Thinking”, represents a contextual mode of analysis. It allows us to adopt targeted actions and to improve and possibly direct and modify non-functional contextual behaviors that interact and can negatively affect the educational concepts that must characterize children’s rugby training [6].

In this way, several frameworks have been concerned with identifying references based on solid pedagogical models for the development of a sports practice aimed not only at performance but also at sports education [7,8]. In an educative vision of sports practice, these pedagogical models must also be applied to children’s sports instructors, as they should extend the sports model to an educational vision that transcends the reductive design of specific interventions with exclusive and limited specialized competitive aims [7–11]. The planning, design, and implementation of model-integrated sports education and initiation pathways [12,13] are characterized by primarily progressive and sequential stages for the education of the body and through the body. These models are intended to guide the development of programs to maintain a positive attitude about sports throughout life. More specifically, they envisage, at the youth level, the construction of physical-motor fundamentals (physical literacy) steps, which are based on a comprehensive multilateral, multi-sport approach [14]. This varied activity makes it possible to add up the training values of different practices while reducing the adverse effects that unilateral sports practice can have [14], also thanks to the attainment of a wider variety of motor skills [15]. However, these models do not always find complete didactic transferability in children’s sports instructor courses, nor has their practical impact on young practitioners always been studied in terms of educational outcomes [10]. Indeed, most federal sports training courses excessively focus on technical elements and performance (ego-oriented [16,17]) that can lead to feelings of inadequacy, excessive competition, and rejection of the activity in their future young athletes, as evidenced by many authors and by an international systematic review [18–20]. In the Italian context, rugby instructors’ training courses are proposed by formators of the rugby federation and are differentiated for technical competence of different ages (Level 1: children, Level 2: adolescents, Level 3: adults) and competitive levels (categories of level 3: C, B, A, excellence; categories of level 4: international rugby championship, national team). Future instructors can choose the formation course that better addresses their certification needs. Nevertheless, the courses attribute the qualification of instructor based primarily on “what to teach” and on knowledge and skills (sometimes only theoretical) to be acquired in planning, mastering, and often evaluating purely technical content [21]. This underscores the need for a more balanced approach in sports instructor’s training, focusing on “how to teach” (methodological competence based on teaching styles) and on instructors’ empathic, emotional, and communication skills (didactical and personal competence based on management capacity and psychological constructs), which are indispensable for positively involving pupils [22]. In particular, a task orientation based on pupil-centered teaching styles seems to positively generate a motivational climate [16,23]. The teaching styles are all the various methodologies that teachers and children’s sports instructors can use to efficiently and effectively achieve the set objective [24]. They include various elements such as the teaching strategies used, the different modalities to propose specific experiences, the methods of communication with the children (for example, need-supportive communication), and the instructor’s attitude towards the learners and teaching (instructors’ personal competence; [25,26]). Different teaching styles, especially in sports practice, allow the development of specific skills linked to the psychomotor, emotional, and self-awareness spheres [27,28]. The continuous variation and the wide use of a spectrum of possible teaching styles during sports practice (multi-teaching style approach [29]) can help to better suit the sports didactics to the specific context and the children’s needs. In a new and unconventional way, the multi-teaching style approach can be considered a non-linear [30] use of pedagogical-didactic methods, as it can be continuously modified and adapted to context and situations, and it should be encouraged to solicit multiple and different aspects of children’s identities. Moreover, using different teaching methodologies could also increase instructors’ awareness of his/her

educative effectiveness [31]. Conversely, the prevalence of a single teaching style more frequently interpreted as a direct, prescriptive, or command style can be considered a linear and limited approach [29,32]. The multi-teaching style primarily relies on intrinsic motivation and enjoyment in children. This methodological model encourages greater decision-making-oriented involvement of child learners by promoting new stimuli that facilitate the development of motor skills and psychological areas [29].

In the teaching and sports education processes as well, the combination, variation, and interaction of teaching styles with reflective practices determine different ways of processing information and responses by learners, allowing for different, personalized learning modes [24,29,33]. Hence, the sports instructor focuses on the teaching activity to carry out and thus on how to teach and why. The instructor's ability to use various teaching styles (methodological competence), didactics competence, and reflection can promote in the child an approach to sports practice that will lead to reaching a healthy and active lifestyle; increased self-awareness and self-body scheme (self-efficacy); greater involvement in sports practice (enjoyment); and maturation of new experiences and motor skills that can also be used in specific sports practice (motor competence) [34]. Figure 1 summarizes the educational vision of sports that underlies this project.

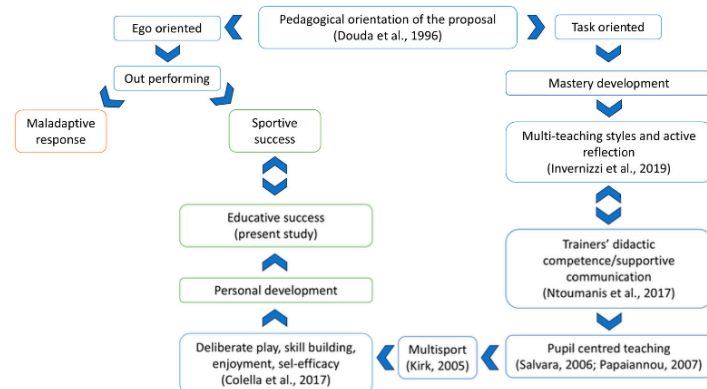


Figure 1. A vision of the youth sports practice aimed at educational and sporting success [14,16,23,26,27,29,35].

In a sports education based on rugby practice, fundamental educative values such as respect for teammates and opponents, collaboration between team members, and resilience while facing difficulties are promoted. These educative values contribute to sports education beyond technical competencies, considering social and emotional aspects essential for success (individual and collective) and for developing a solid and adaptable character [36]. The teaching duality of sport and educative success in this discipline requires training to develop an adequate practice finalized on objectives that can focus on both dimensions (technical and socio-emotional). Hence, the instructors' didactical/methodological capacities and the training sessions design become essential when creating a specific environment to improve life and sports competence [37]. Scientific literature considers approaches such as teaching games for understanding and tactical game approaches particularly suitable for this sport. Moreover, the child-centered approach (production teaching styles) is considered adequate for rugby's sports practice, as it is based on a teaching-learning process conceived on individual characteristics, needs, and motivations [38,39]. Nevertheless, to the best of our knowledge, no studies have specifically addressed the teaching styles used by rugby instructors.

Aims

The present research analyzed rugby instructors' didactical (their communicative and organizational abilities and group management) and methodological competencies (the teaching styles they used), investigating the relationships between them. The relationship between motor coordination and psychological aspects (self-perception and enjoyment) in the children trained with and without a multi-teaching methodology by the instructors participating in this study was further analyzed. Finally, instructors' personal competencies, such as empathy and self-control, and their correlations with the psychological areas (enjoyment and self-efficacy) of children were investigated.

2. Materials and Methods

2.1. Sample

Before planning and offering a course for instructors of youth sports, researchers by the University of Milan wanted to explore the context of sports clubs where courses would be applied (which is the core of the present research). Hence, 50 Italian rugby instructors from the youth sector of the local area (two Italian rugby clubs of the Lombardy region) and their respective trained children were recruited. The statistical power resulting from this instructor sample was 0.81. The statistical power was calculated with the G*Power program using an effect size estimate (Cohen's *d*) of 0.5. For this calculation, the student *t*-test for unpaired data was chosen. The same calculation was used to estimate the number of children required. An amount of 210 pupils allowed a statistical power of 95%; hence, a sample of 220 children was enrolled. Anthropometric data of children and instructors' samples are displayed in Table 1.

Table 1. Anthropometric data of the sample.

	Children	Instructors
Sample size (n°)	220	50
Age (years)	9.6 ± 1.1	39.0 ± 13.6
Males (n°)	216	45
Females (n°)	4	5
Weight (Kg)	36.0 ± 7.5	
Height (m)	1.4 ± 0.1	
BMI (kg/m ⁻²)	18.6 ± 3.3	
Rugby teaching experience (years)		6.0 ± 5.7

2.2. Instructors' Background

The rugby instructors participating in the study were all certified by the Italian Rugby Federation (FIR) as "level 1 (children)" instructors. This certification allows instructors to train children from 5 (under 6) to 12 (under 12) years old. Approximately 70% of the recruited instructors had experience as rugby players, 25% came from other sports, and 5% had no sport experience. None of the participants came from a specific sport science university course.

2.3. Protocol

Instructors' behavior (didactic competence) was defined by a list of descriptors used to promote motor tasks and the need for supportive communication. Didactics competencies were assessed during usual rugby training, at the beginning of the sport season, using a modified version of the "Internship Evaluation Sheet in Physical Education and Sports" (IESPES; Table 2; [40–43]).

Table 2. IESPES items' descriptors.

Items	Descriptors ¹
Verbal communication	Comprehension; logic; choice of words of appreciation; choice of words of reproach; use of metaphors/narration.
Voice and paralinguage	Volume; timbre; modulation; expository rhythm; use of silences and pauses.
Non-verbal communication	Facial expression; eye gaze; eye contact; posture; proxemics gestures.
Specific didactics	Choice of exercises; progression; demonstration; correction; adaptation of the proposal.
Elements of organizational references	Location of tools; location in space of learners; safety/prevention/assistance rules; use of conceptual diagrams/charts/illustrations; time management (activity times; question times; organizational times).
Psychological references	Interest aroused; emulation level; expectations/requests; reinforcement; contextualization.
Personal competence	Charisma; accuracy; confidence; empathy; self-monitoring

¹ Instructors were evaluated on five descriptors for each item [40–43]. The descriptors were scored as 0 (=inadequate) or 1 (=adequate) point, returning a score ranging from 0 to 5 for each item. The final score was calculated as the mean of all items' scores.

Methodological competencies were investigated through the Teaching Styles Questionnaire (TSQ) [44,45], a self-reported questionnaire about the teaching styles used by the instructors.

IFITS and SOFITS systems were employed to verify the effectiveness of the instructors' use of different teaching styles, the physical activity level, the children's physical activity level, and the instructor's interaction capacity during regular rugby training at the beginning of the sports season [46,47].

Instructors' personal competence was investigated through the Empathy Scale for Teachers (EST) [48] and the Self-Control Questionnaire (SCQ) [49].

In children, for the evaluation of motor competence, we utilized the Körperkoordinations- und Kognitions-Test für Kinder (KTK) to assess coordination skills [50] and the Game Performance Assessment Instrument (GPAI) to assess game comprehension and sport-specific skills execution [51]. These practical and effective tools were complemented by three questionnaires to investigate self-perception [52], enjoyment [53], and the type of physical activity performed [54].

2.4. Measures

2.4.1. Instructor's Group

1. The Teaching Styles Questionnaire (TSQ; [44,45]) is designed to examine teachers' teaching style methods, and it has been used to evaluate sports instructors [24]. The TSQ is based on the spectrum of teaching styles classified by [55]. The questionnaire presents for each teaching style a five-point Likert scale score. Points near to 5 express a frequent use of the teaching styles, while points near to 1 mean that it is not used.
2. The Internship Evaluation Sheet in Physical Education and Sports (IESPES; [40,42]) is a tool designed to evaluate the instructors' didactic competence. A score from zero to five points was attributed to communication capacity (verbal communication, voice, paralinguage, non-verbal communication), didactics organization (specific didactics, elements of organizational references), and capacity to motivate and to engage the pupils (psychological references, personal competence).
3. The Empathy Scale for Teachers [48] is a self-evaluation questionnaire developed to measure educators' empathy capacity in educational contexts. The questionnaire is composed of 19 questions with answers on a four-point Likert scale. The questionnaire

reports an empathy final total score and three sub-scores related to cognitive, positive affective, and negative affective empathy.

4. The Self-Control Questionnaire [49] is an evaluation tool for the measure of self-control. It is composed of items rated on a five-point scale, starting from 1 (“not at all like me”) to 5 (“very much like me”). The questionnaire, composed of 36 items, reports a final self-control total score and eight subscale scores (impulse control, goal setting, distraction control, self-monitoring, task initiation, emotion regulation, automaticity, and decision-making).
5. Video analysis IFITS [47] and SOFIT [46]. Two lessons at the beginning of the sport season were video recorded, and the IFITS and SOFIT analysis systems were used to verify the instructors’ teaching styles, the children’s levels of physical commitment during the lessons, and the interaction capacity of instructors with them. The IFITS instrument gives the % of time spent on each instructor’s teaching style. The SOFIT instrument gives the % of time spent in sedentary behaviors (lay, sit, stand) or moderate to vigorous physical activity (walk or vigorous activity), the % of time spent for each lesson content (skills, game, fitness, management, knowledge, or other contents) and the % of time spent by the instructor in motivating children to activity (motivation focused on the inside lesson topic or outside lesson topic or not motivating).

2.4.2. Children’s Group

1. Körperkoordinationstest für Kinder (KTK, [50]) is a coordinative test for children from 8 to 14 years old. It includes four tests (walking back, jumping sideways, moving sideways, and hopping for height). The result of each test is normalized, converted, and summed into a total motor quotient score (MQ) using a dedicated nomogram. The MQ indicates the children’s level of body mastery that can be allocated into six ranges: disturbed (MQ = 50–70), noticeable (MQ = 71–85), average (MQ = 86–115), good (MQ = 116–130), and excellent (MQ = 131–145).
2. The Physical Activity Questionnaire for Older Children (PAQ-C; [54]) was employed to determine the level of physical activity in the last seven days. Low scores (from 1 to 2.33) correspond to a low level of physical activity; medium scores are related to a moderate level (from 2.34 to 3.66) of physical activity, while high scores (from 3.67 to 5.00) imply a high level of physical activity.
3. The Game Performance Assessment Instrument (GPAI; [51]) is a validated tool that assesses children’s ability to perform during sports games. The instrument evaluates the appropriate decisions or tactical executions, as well as the efficiency of skills performed during the game. In the present analysis, 15 min of matches during rugby training were evaluated. Due to the high number of children, the present study focused the analysis only on the offensive phases and considered the scores performed by the overall team without analyzing single players’ outcomes. The game variables considered were decision-making, skill execution, support, and game performance.
4. The Physical Activity Enjoyment Scale (PACES; [56]) is a 16-item questionnaire that uses a five-point Likert scale (1: completely disagree, 2: disagree, 3: uncertain, 4: agree, 5: fully agree). The questionnaire gives a final total score ranging from 16 to 80; higher values are related to higher enjoyment of the physical activity proposed.
5. The Physical Self-Efficacy Scale for children (PSES; [52]) is a test that evaluates the self-perception of one’s physical efficiency in motor skills, considered a primary motivational factor for voluntary participation in any physical activity and sport. It is composed of six questions and comprises a four-point Likert scale. The questionnaire gives a final total score ranging from 6 to 24; higher values are related to a more positive perception of the self.

This study was approved by the ethical committee of the University of Milan on 13 February 2024 with opinion number 14/24.

2.5. Reliability of Internship Evaluation Sheet and Video Analysis

To evaluate the intra- and inter-rater reliability of IESPES, SOFIT, and IFITS, a video of 10 instructors' internships and the children's training (six trainings) was recorded. Three different operators who were adequately trained to use the internship evaluation sheet analyzed the video. Every operator repeated the evaluation after two weeks. The video sequence was randomly assigned.

The GPAI intra- and inter-rater reliability process followed the same procedure but was based on videos of two different matches.

2.6. Statistical Analysis

The normal data distribution has been verified using the Shapiro-Wilk test.

The intra-rater and inter-rater reliability of IESPES was assessed using the intraclass correlation coefficient (ICC). A reliability value above 0.70 was considered sufficient for the evaluation.

For the GPAI, IFITS, and SOFIT evaluation reliability, the following formula was used to assess the percentage of agreement between and within raters [57,58]:

$$\% \text{ agreement} = n^{\circ} \text{ agreement} / (n^{\circ} \text{ agreement} + n^{\circ} \text{ disagreement}) \times 100$$

An agreement rate of over 80% was deemed necessary for the test to be considered reliable.

The differences in IESPES, self-reported teaching styles, IFITS, SOFIT, KTK, and GPAI results were investigated using the two-way ANOVA or the respective non-parametric Friedman test.

The Spearman correlation was performed to investigate the relationship between instructors' teaching styles and instructors' didactic competence (IESPES). Moreover, to assess relationships between instructors' characteristics and children's outcomes, two groups of instructors, a multi-teaching group (MG), and a non-multi-teaching group (NMG) were established considering the results of the self-reported questionnaire (TSQ). Instructors who used many teaching styles were enrolled in the MG, and those who used only one or two teaching styles were enrolled in the NMG. In this division, we used the results of the teaching styles questionnaire and not the results of IFITS because the former concerned the entire experience of the instructor, while the latter referred to the observational analysis of only two lessons.

Spearman's correlation was applied to relate (i) self-reported teaching styles and IESPES outcomes; (ii) KTK normalized score and enjoyment in multi-teaching children; (iii) KTK normalized score and enjoyment in non-multi-teaching children; (iv) KTK normalized score and self-efficacy in multi-teaching children; and (v) KTK normalized score and self-efficacy in non-multi-teaching children.

Finally, to assess relationships between children's psychological aspects (enjoyment and self-efficacy) and instructors' personal competencies (empathy and self-control), no instructor group division was performed, as we used the percentages of the questionnaires' results. Hence, the correlations were assessed using Spearman's correlation.

For all mentioned analyses, the level of significance was set at 0.05.

A descriptive statistic was used for PACES, PSES, and PAQ-C general outcomes.

3. Results

3.1. Reliability Results

The IESPES obtained values of intra-rater ICC higher than 0.852 and inter-rater ICC higher than 0.886. GPAI, IFITS, and SOFIT evaluations obtained values of agreement higher than 82% for intra- and inter-rater reliability.

3.2. Instructors' Descriptive Results

3.2.1. IESPES Results

The ANOVA test revealed significant differences in IESPES results ($p < 0.001$, $\eta^2 = 0.13$). Post hoc analysis revealed that verbal communication was the higher value obtained by rugby instructors ($p < 0.05$). Only the organizational elements item did not significantly differ from verbal communication in the post hoc analysis ($p = 0.09$). The results are displayed in Figure 2.

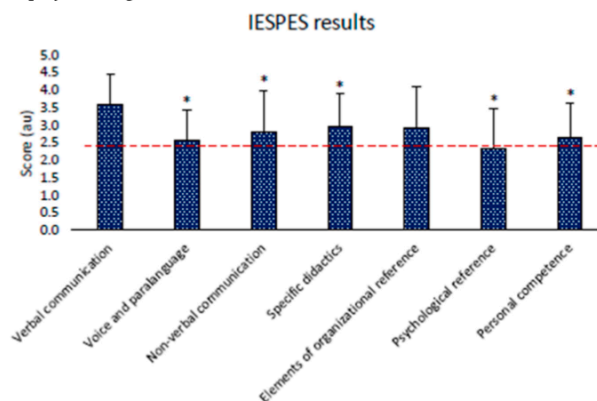


Figure 2. IESPES results. The red dashed line represents the minimum teaching competence score. Difference with “verbal communication”: * = $p < 0.05$.

3.2.2. Self-Reported Teaching Styles Questionnaire's Results

The Friedman test for the self-reported teaching styles resulted in significance ($p < 0.001$). Post hoc analysis revealed significantly higher values for the command and practice (a and b) teaching styles ($p < 0.05$) and lower values for all other teaching styles. All post hoc analysis results are displayed in Figure 3.

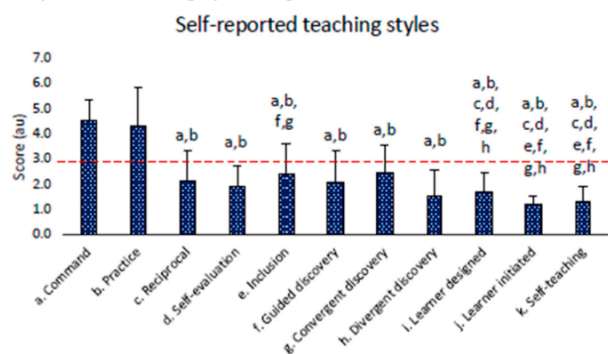


Figure 3. Results of the self-reported teaching styles questionnaire. The red dashed line represents the value referred to as the “here and there” descriptor and was interpreted as the minimum arbitrary value (set at 60% of the total score) to consider a teaching style sufficiently used during training. Letters indicate a significant difference with the respective teaching style ($p < 0.05$).

3.2.3. Teaching Styles' Video Analysis Results (IFITS)

The Friedman test resulted in significance for IFITS analysis ($p < 0.001$). The post hoc analysis revealed that command style and practice are the only styles used, confirming the prevalence of these methodologies. Between the two, in the lessons analyzed, the command style was the teaching style less frequently used (13.2 ± 18.2 % of lesson, $p = 0.004$), while most of the time was spent with the practice teaching style (51.1 ± 28.4 % of lesson) and management activities (35.7 ± 17.7 % of lesson). Results are displayed in Figure 4.

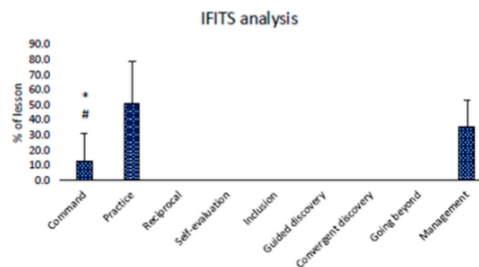


Figure 4. Results of IFITS analysis. Different than practice: * = $p < 0.05$. Different than management: # = $p < 0.05$.

3.2.4. Physical Activity's Video Analysis Results

Friedman's analysis of players' activity showed significant differences ($p < 0.001$). The post hoc analysis revealed that the main part of the lessons was spent in standing (30.1 ± 15.4 % of the lesson), moderate (26.8 ± 11.6 % of the lesson), and vigorous (40.1 ± 13.2 % of the lesson) physical activity. Concerning instructors' interaction with children, the Friedman analysis showed that most instructors did not interact with children during lessons, few of them interacted by focusing on inside lesson topics, and none of them interacted by focusing on outside lesson topics. Finally, the main content of rugby lessons was directed toward improving specific rugby skills. Figure 5 shows all significant differences.

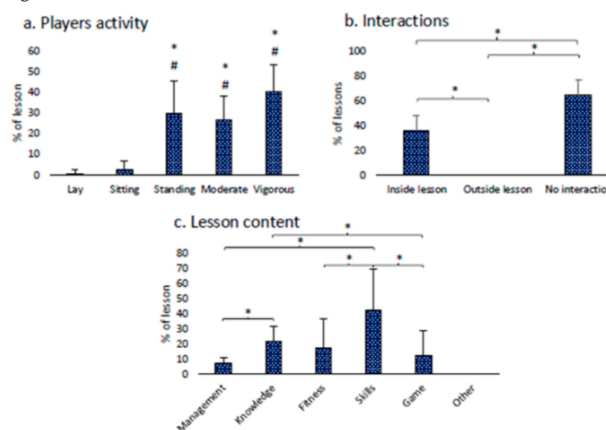


Figure 5. Results of SOFIT players activity (a), instructors interactions (b), and lesson content (c). Panel (a): different than lay: * = $p < 0.05$; different than sitting: # = $p < 0.05$. Panel (b): significant difference: * = $p < 0.05$. Panel (c): significant difference: * = $p < 0.05$.

3.2.5. Empathy Scale for Teachers (EST) Results

Regarding instructors' empathy, the positive affective empathy result was the lower value ($p < 0.05$) and the one lower than 60%, while the higher values reported were the negative affective empathy and the cognitive empathy. The results of the Empathy Scale for Teachers are displayed in Figure 6.

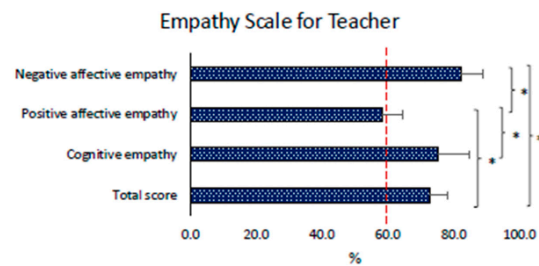


Figure 6. Instructors' empathy descriptive results. The red dashed line represents the cut-off line of low (<60%) or high (>60%) empathy. * = significant difference ($p < 0.05$).

3.2.6. Self-Control Scale Results

The Self-Control Questionnaire revealed that the instructors' sample had high values of emotion regulation, task initiation, self-monitoring, distraction, and impulse control. Conversely, the sample reported low values of decision-making, automaticity, and goal-setting (all close to 60% of the maximal reachable score). The statistical results of Friedman's comparison are reported in Figure 7.



Figure 7. Instructors' self-control descriptive results. The red dashed line represents the cut-off line of low (<60%) or high (>60%) self-control. Letters indicate significant difference with the respective self-control scale ($p < 0.05$).

3.3. Children's Descriptive Results

3.3.1. Körperkoordinationstest für Kinder Results (KTK)

The two-way ANOVA revealed a significant difference between KTK sub-tests ($p < 0.001$). The post hoc analysis revealed that the higher scores were performed in single leg jump (96.3 ± 12.9 au) and side jumps (92.1 ± 23.1 au), which reached the normal score range (between 85 and 115 au). Other results are displayed in Figure 8.



Figure 8. Results of KTK analysis. Significantly different than translocations: \$ = $p < 0.05$; significantly different than side jumps: # = $p < 0.05$; significantly different than single leg jump: * = $p < 0.05$. Red dashed lines represent the coordination normality range between 85 and 115 au. MQ = motor quotient.

3.3.2. Game Performance Assessment Instrument Results (GPAI)

The Friedman analysis revealed that the children made higher percentages of appropriate decisions ($71.5 \pm 7.7\%$) compared with efficient skill execution, which resulted in low percentages ($47.8 \pm 10.5\%$). No differences were detected with performance level ($59.7 \pm 5.8\%$). Results are displayed in Figure 9.

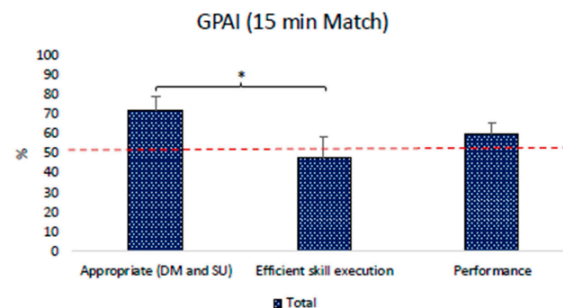


Figure 9. GPAI results. The red dashed line represents 50% of the total decision and execution performed. * = $p < 0.05$. Appropriate (DM and SU) = % of appropriate choices on the total choices (summing decision-making choices and teammate support) determined by the team; efficient skill execution = % of efficient skills execution on the total of the skills executed during the video recording; performance = % of success related to the efficient execution of the appropriate choice made by children [59].

3.3.3. Questionnaires Descriptive Results

Table 3 displays the results of the questionnaire and KTK reached by children and the % of maximal reachable points.

Table 3. Questionnaire results and % of maximal reachable point.

	Total Scores ^a	Maximal Reachable Points	% of Maximal Reachable Point ^a
PACES (au)	69.8 ± 6.6	80	87.3 ± 8.2
PSES (au)	17.0 ± 2.4	24	70.6 ± 9.9
PAQ-C (au)	2.7 ± 0.6	5	54.6 ± 12.0

^a Mean ± standard deviation.

3.4. Correlation Results

3.4.1. Correlation Between Teaching Styles and IESPES Results

Correlation between teaching styles questionnaire results and IESPES results has been performed. For this analysis, the items “verbal communication”, “voice”, and “non-verbal communication” were summed in the “communication” category. In the same way, “didactics” and “organizational elements” were summed in the “didactics” category, while “psychological elements” and “personal competence” were summed into the “motivation and personal competence” category. Moreover, teaching styles questionnaire results were summarized in “multi teaching” (number of teaching styles evaluated as four and five, respectively “very often” and “most of the time”), reproduction (number of reproductive teaching styles evaluated as four or five), and production (number of productive teaching styles evaluated as four or five). Data were analyzed using Spearman’s correlation. Results are summarized in Table 4. Primary correlations are displayed in Figures 10–12.

Table 4. Results of correlation analysis between teaching styles and IESPES results.

		Multi-Teaching	Reproduction	Production	Communication	Didactics	MPC ¹	Total Score
Multi-teaching	rho	1	−0.136	0.195	0.661 **	0.486 **	0.344 *	0.323 *
	p-value	-	0.346	0.174	<0.001	<0.001	0.014	0.022
Reproduction	rho	-	1	−0.072	0.400 **	0.341 *	0.137	0.335 *
	p-value	-	-	0.618	0.004	0.015	0.342	0.017
Production	rho	-	-	1	0.564 **	0.420 **	0.283 *	0.293 *
	p-value	-	-	-	<0.001	0.002	0.046	0.039
Communication	rho	-	-	-	1	0.747 **	0.479 **	0.542 **
	p-value	-	-	-	-	<0.001	<0.001	<0.001
Didactics	rho	-	-	-	-	1	0.538 **	0.792 **
	p-value	-	-	-	-	-	<0.001	<0.001
MPC ¹	rho	-	-	-	-	-	1	−0.04
	p-value	-	-	-	-	-	-	0.782
Total score	rho	-	-	-	-	-	-	1
	p-value	-	-	-	-	-	-	-

¹ MPC = Motivation and personal competence. * = $p < 0.05$, ** = $p < 0.001$.

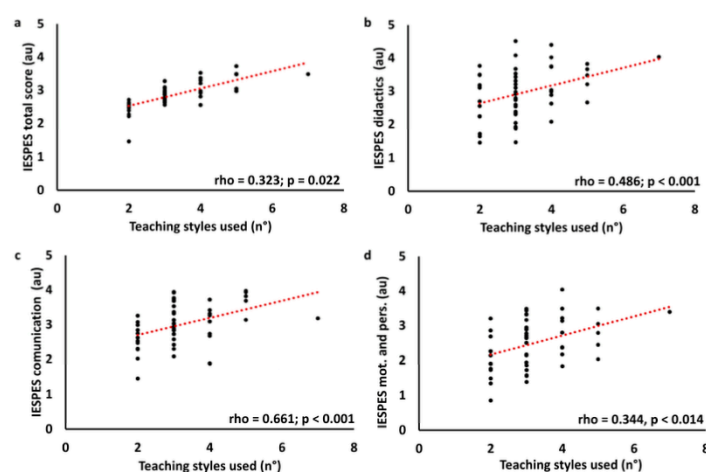


Figure 10. Correlation graph between IESPES scores and the number of teaching styles prevalently used. IESPES scores: total score (a), didactics (b), communication (c), motivation and personal competence (d).

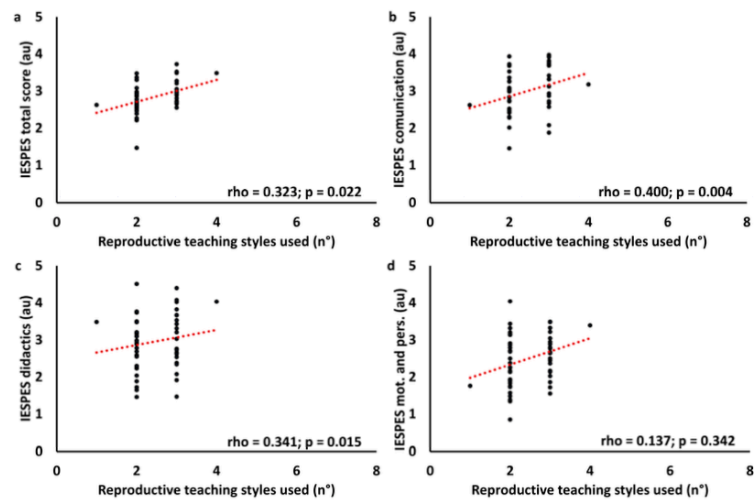


Figure 11. Correlation graph between IESPES scores and the number of reproductive teaching styles prevalently used. IESPES scores: total score (a), didactics (b), communication (c), motivation, and personal competence (d).

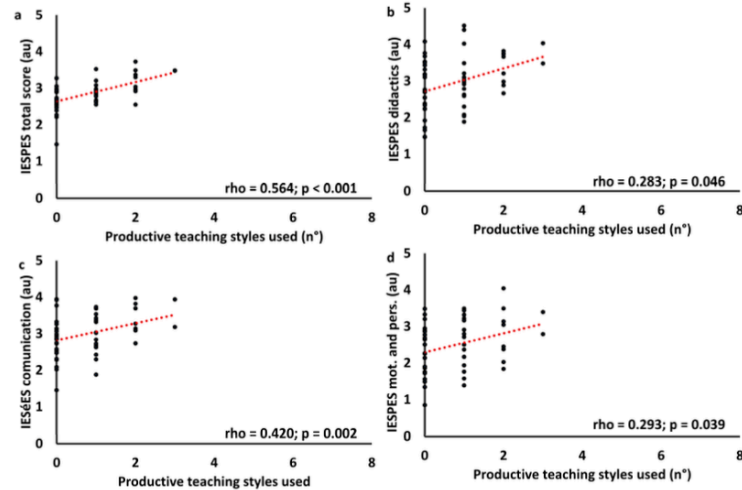


Figure 12. Correlation graph between IESPES scores and the number of productive teaching styles prevalently used. IESPES scores: total score (a), didactics (b), communication (c), and motivation and personal competence (d).

3.4.2. Correlation Results Between Motor Competence, Self-Efficacy, and Enjoyment in Children with Multi-Teaching and Non-Multi-Teaching Instructors

Spearman's correlations were performed to evaluate the relationships between motor competence and psychological aspects in children with multi-teaching and non-multi-teaching trainers. Results are reported in Tables 5 and 6 and in Figures 13 and 14.

Table 5. Correlation results between motor competence (KTK, PAQ-C), self-efficacy (PSES), and enjoyment (PACES) in children with multi-teaching trainers.

Children with Multi-Teaching Trainers		Normalized Total MQ	PACES	PSES	PAQ-C
Normalized total MQ	rho	1	0.741 **	0.727 **	0.089
	p-value	-	<0.001	<0.001	0.383
PACES	rho	-	1	0.622 **	0.167
	p-value	-	-	<0.001	0.1
PSES	rho	-	-	1	0.102
	p-value	-	-	-	0.317
PAQ-C	rho	-	-	-	1
	p-value	-	-	-	-

** = $p < 0.001$.

Table 6. Correlation results between motor competence (KTK, PAQ-C), self-efficacy (PSES), and enjoyment (PACES) in children with non-multi-teaching trainers.

Children with Non-Multi-Teaching Trainers		Normalized Total MQ	PACES	PSES	PAQ-C
Normalized total MQ	rho	1	0.127	0.217 *	0.16
	p-value	-	0.203	0.029	0.107
PACES	rho	-	1	-0.059	-0.011
	p-value	-	-	0.556	0.91
PSES	rho	-	-	1	0.393 **
	p-value	-	-	-	<0.001
PAQ-C	rho	-	-	-	1
	p-value	-	-	-	-

* = $p < 0.05$, ** = $p < 0.001$.

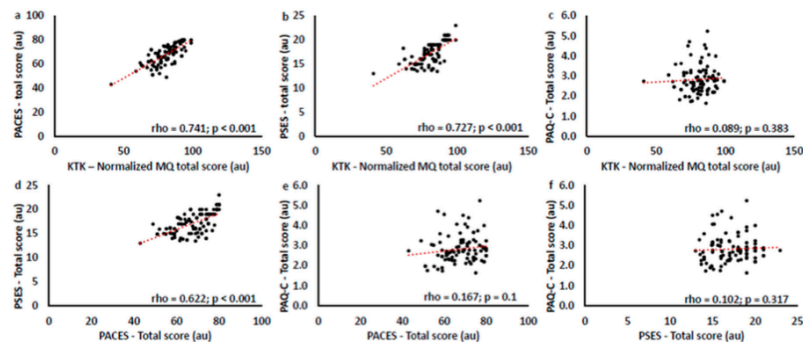


Figure 13. Correlation graphs between KTK and PACES (a), KTK and PSES (b), KTK and PAQ-C (c), PACES and PSES (d), PACES and PAQ-C (e), and PSES and PAQ-C (f). The sample considered is children with multi-teaching trainers.

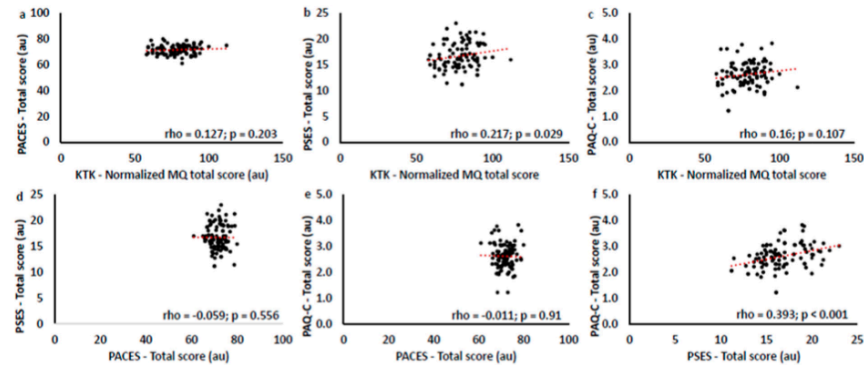


Figure 14. Correlation graphs between KTK and PACES (a), KTK and PSES (b), KTK and PAQ-C (c), PACES and PSES (d), PACES and PAQ-C (e), and PSES and PAQ-C (f). The sample considered is children with non-multi-teaching trainers.

3.4.3. Correlation Analysis of Enjoyment and Self-Efficacy with Instructors' Empathy and Self-Control

Spearman's correlations were performed to evaluate the relationships between children's psychological aspects (enjoyment and self-efficacy) and instructors' interpersonal competence (empathy and self-control). The main results are shown in Tables 7 and 8, while Appendix A (Table A1) displays the complete correlation table.

Table 7. Main results of enjoyment correlation table.

(a)			Empathy						
	Enjoyment	Total %	Cognitive Empathy %		Positive Affective Empathy %	Negative Affective Empathy %			
Enjoyment	1	0.281 **	0.135		0.726 **	0.019			
(b)			Self-Control						
	Total	IC	GS	DC	SM	TI	ER	AU	DM
Enjoyment	0.158 *	−0.202 **	0.296 **	0.098	0.322 **	−0.298 **	0.105	−0.255 **	0.158 *

Tables show rho values of the correlation of children's enjoyment vs. instructor's empathy variables (7a) and children's enjoyment vs. instructor's self-control (7b) variables. IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision making. * = $p < 0.05$, ** = $p < 0.01$.

Table 8. Main results of the self-efficacy correlation table.

(a)			Empathy						
	Enjoyment	Total %		Cognitive Empathy %		Positive Affective Empathy %		Negative Affective Empathy %	
Self-efficacy	1	0.397 **		0.288 **		0.288 **		0.223 **	
(b)			Self-Control						
	Total	IC	GS	DC	SM	TI	ER	AU	DM
Self-efficacy	−0.107	−0.013	−0.325 **	−0.031	0.296 **	0.035	−0.092	0.092	−0.324 **

Tables show rho values of the correlation of children's self-efficacy vs. instructor's empathy variables (8a) and children's self-efficacy vs. instructor's self-control (8b) variables. IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision making. ** = $p < 0.01$.

4. Discussion

The present research aimed to evaluate the correlation between the rugby instructors' methodological competencies and their didactic competence. Moreover, this study aimed to evaluate and compare the effects of the variation in the teaching styles used on motor competence, self-perception, and enjoyment in children who received a multi-teaching style approach and children who did not.

From the results that emerged from this study, considering a mean score of 3 au (60% of maximal score), we can affirm that concerning didactics competencies, the instructors had good verbal communication skills, sufficient organizational skills, and specific didactics skills (exercises' choices, demonstrations, corrections, etc.). Nevertheless, they reported poor non-verbal communication (facial expressions, posture, gestures, proxemic gestures, etc.), personal competence (charisma, empathy, self-monitoring, etc.), skills in managing voice and paralinguages (volume, timbre, modulation, etc.), and psychological references (interest arouse, emulative level, reinforcements, etc.). Considering the statistical analysis, organizational skills were the only descriptor that did not differ from verbal communication. All the other descriptors indicated the need for intervention oriented to their improvement. The capacity to positively manage the different didactic competencies represents a key element in understanding how to help young people develop and maintain adequate physical literacy for sports and educational success [60]. Concerning methodological competencies, according to a recent study, instructors revealed, through self-reported teaching styles, a prevalent use of the command and practice styles. In line with our results, Fernandez et al. (2021) reported that federal instructors use these styles more frequently; conversely, specialized PE teachers use a multi-teaching styles approach in sports education [61].

Video analysis (IFITS analysis) showed that instructors exclusively used command and practice styles (mainly used). Furthermore, substantial time was needed to manage the activities, demonstrating poor employment of effective didactics. The instructors' poor time management capacity seems to contradict the IESPES organizational skills outcomes; nevertheless, the time management represents just one of the five descriptors that compose the evaluation. This should mean that even if rugby instructors are sufficiently able to spatially organize the lesson (considering location of tools, location of learners, safety/prevention/assistance rules, use of conceptual illustrations), they have difficulties in managing time during training. The children's sports sphere represents the most appropriate sample to experiment with and check various learning approaches that could stimulate active participation and personal development. Nevertheless, the limited instructors' didactics and methodological skills represent a significant barrier to achieving these objectives [62].

Concerning physical activity involvement evaluated through the SOFIT system, time spent in moderate and vigorous physical activity (MVPA) is greater than time spent sitting or lying, but considerable time is spent staying still. Deepening the analysis, the contents of the proposed activities are much more dedicated to skills learning than games and fitness, similar to cases highlighted by literature [63]. The instructor-children relationship during lessons is poor, and feedback is only related to the on-field practice. No instructor promotes the transferability of the practice of other activities or contexts necessary to promote a multi-sportive education and a more comprehensive promotion of physical activity even outside sport-specific practice [64].

The Self-Control Questionnaire and the Empathy Scale for Teachers, which highlight higher levels of emotion regulation, and low results of positive affective empathy can constitute two personal competencies to be considered as elements to be improved to promote educational interaction with pupils [65,66].

Correlation analysis between internship score (didactic competence) and the number of teaching styles used (methodological competence) showed a positive relationship between multi-teaching productive style and the total score reached in total didactic competence, organizational elements, specific didactics, motivation, and personal competence of

the instructor. The correlations of the didactic competence with the number of reproductive styles used show the same results, except for the motivation/personal competence. These results agreed with Rivera-Perez (2020), who showed that multi-teaching motor tasks, both with reproduction styles (reciprocal, self-check following specific criteria) and production styles (divergent discovery for small groups), favor the development of soft skills emphasized with relationship dynamics in children and adolescents [28]. Communication skills are more related to positive correlations with didactics' organizational and managing aspects, motivation/personal competence, and total score, confirming that didactics could be considered a communication science [43].

Considering the results of the analyzed children sample, the outcomes of motor competence in children present under motor normality levels, referring to the motor quotient of the KTK test. Similarly, game performance, determined by GPAL, evidenced results of less than 50% of effective skills executions despite the appropriate choices related to situational needs. The acquisition of adequate coordination could positively affect sport-specific skill learning. Indeed, skill competence could improve game comprehension, reducing failure after a good tactical choice depended on bad skill management [67]. Notably, El Khouri evaluated the effects of two learning units based on command and guided discovery styles on the gymnastics skills of two groups of children [68]. Although learning results were similar in the two groups, the guided discovery styles guarantee better learning retention from the medium to long term than the command styles. Furthermore, Da Silva showed how production styles, weakly used in our study by the rugby instructors, improved the learning of sport-oriented skills in team sports, such as decision-making, appropriate choice selection, and being active and involved in the games [69].

Preliminary results of the children's questionnaires evidenced high scores related to enjoyment and self-efficacy but insufficient general physical commitment of children concerning the total physical activity done. The correspondence between teaching and learning is determined by the choices and didactical decisions made, the questions the instructor formulates, and the expected responses (related to what task and how to execute). As previously highlighted in SOFIT, the poor interaction of the instructors in promoting further different sports and activities outside of rugby lessons may have influenced these results [63,64]. Referring to the correlation between children's psychological constructs (physical self-perception and enjoyment) and motor competence in MG and NMG, MG showed a strong correlation with motor competence, enjoyment, and physical self-efficacy, and NMG showed a weak correlation between competence and self-efficacy. Self-perception and enjoyment development are interdependent because they are the outcomes of motor tasks successfully executed and from their previous skills. Understanding how teaching styles vary and are interconnected is crucial for assessing the effects on motor learning and related psychological factors [70,71]. Motor competence is related to the type and variety of teaching styles used for positive living and their relationship with children's self-perception, which could sustain motor and sports practices [52,53]. This analysis suggests that research perspectives will have to proceed in different and complementary directions: on the one hand, through the sports training of instructors through evidence-based didactics, and on the other, through analyses and studies geared towards enhancing not only motor performance (sporting success) but also the underlying psychological and social factors (educational success) [16,17]. Rugby instructors' training courses must include significant experience in sports activity methodology and psycho-pedagogical sensitivity for children and young people.

Instructor's empathy and self-control are closely related to the children's positive psychological approach to the lessons [66]. More specifically, in our study, empathy correlates with enjoyment and self-efficacy in children. These results are consistent with the literature, highlighting how this personal competence is an indispensable characteristic of an engaging instructor who does not demotivate children [25]. Regarding self-control, an instructor's excess of dirigisme and inhibitory behavior could negatively affect the children's intrinsic motivation and determine relational problems [72]. In particular, an

excessive definition of objective can lead to an excessive definition of executive rules with a greater possibility of children's failure and a lower sense of self-efficacy [73]. Similarly, the teacher with an excess of decision-making takes away decision-making autonomy from the children and, therefore, negatively influences their perception of self-efficacy. Regarding the relationship between self-control and enjoyment, an excess of impulse control and automaticity could reduce teacher creativity and spontaneity in lessons; an excess of task initiation could induce excessive pressure with a misunderstanding of the proposal and minor engagement [74–76]. A more frequent use of student-centered production styles and supportive communication could help solve these problems [23,26,77]. This concept agrees with the principle of self-determination theory and need-supportive communication. It highlights how autonomy and the discreet presence of the instructor, who must be present but let children experiment without doing things in their place, are critical elements of an effective sport and formative success with children [26]. Finally, correlation results highlighted a direct relationship between both enjoyment and self-efficacy with self-monitoring (as part of the Self-Control Questionnaire). This means that a more reflective instructor who knows how to think about his/her behavior, proposal, and relationships during a training session can modify, implement, and improve the lesson for the pupils he/she is referring to when required. This way, the instructors' self-monitoring capacity could lead to a higher enjoyment of the sports practice and a higher sense of efficacy in children [29,78].

Limitations of the Study

Two main limitations can be acknowledged in the present study. The geographical area of the rugby clubs from which participants were involved in the research was limited to the local area near the researchers' university in northern Italy. This could represent a relevant issue possibly affecting the generalizability of the results as sensible differences with other local areas surely exist with respect to facilities and/or rugby popularity and diffusion. Moreover, rugby is a sport prevalently practiced in Italy by male players and has few young female rugby players. For this reason, gender comparison has not been possible.

5. Conclusions

In a concept of rugby-oriented system thinking, our study well evidences the relationship between different instructors' learning skills and educational success (Figure 15).

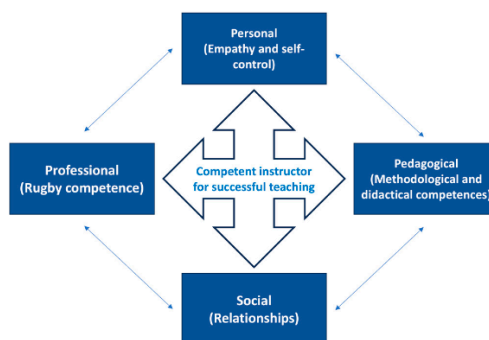


Figure 15. Summary table of the relationship between the emerging learning skills of this study.

The multi-teaching methodological approach and the connection with instructors' communicative teaching and empathic engagement skills positively influence the relationships between motor competence and the effects on children's psychological components. This interconnection highlights the importance of orienting instructor training toward the

ability to use varied teaching styles, especially production styles, which is a key leverage point for the educational success of their practice [29].

A point of resistance that emerges from this analysis is the pupils' poor general motor competence, evidenced by the KTK, the GPAL, and the SOFIT observation of the instructors' poor interaction and involvement in promoting multilateral and multi-sportive motor practice in children, also carried out in the lessons [64]. Loop research between instructor/children variables to determine the effects of reciprocal interactions (circular loop based on "causal relationship chains" of direct and opposite return directions) supports a training approach based on instructors' methodological learning [79].

Instructors' use of different teaching styles and multisport and multilateral practice may constitute the most critical variations in an approach that must always be oriented more toward educational success than only toward young people's sports performance.

5.1. Practical Application

The present research established that training rugby instructors utilizing a multi-teaching reflective approach and implementing the children's interaction in promoting multi-sports activity outside lessons [14,29] could effectively contribute to creating the proper educational and methodological competence oriented to support both the sport and the educational success of young rugby players. In addition, empathic and self-monitoring capacities resulted related to children's psychological well-being, expanding the need for qualified instructors having technical skills to develop didactical and methodological competencies granting positive motor and psychological results. That can favor rugby performance and the development of a child's physical literacy.

5.2. Future Research Development

Studies and research need to be more frequently and systematically integrated into the settings where the teaching process occurs. In addition, studies on the teaching methods implemented in the different disciplines should be expanded and made more common to indirectly acquire knowledge on how children learn sports motor skills. Future studies should focus on the efficacy and transferability of instructors' courses based on a multi-sports and multi-teaching reflective approach to advance scientific evidence.

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Data Availability Statement: The data presented in this study are available on request from the first and second authors due to privacy reasons.

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Appendix A

Table A1. Correlation analysis of enjoyment and self-efficacy with instructors’ empathy and self-control.

PACES		PSES	Empathy Scale for Teachers					Self-Control Scale							
Enjoyment		Self-Efficacy	Total%	CE%	PAE%	NAE%	Total%	IC%	GS%	DC%	SM%	TI%	ER%	AU%	DM%
PACES	Enjoyment	1	0.303 **	0.281 **	0.135	0.726 **	0.019	0.094	0.158 *	0.296 **	0.098	0.322 **	−0.298 **	0.105	−0.255 **
PSES	Self-efficacy	1	0.397 **	0.288 **	0.288 **	0.223 **	−0.107	−0.013	−0.325 **	−0.031	0.296 **	0.035	−0.092	0.092	−0.324 **
Empathy Scale for Teachers	Total%		1	0.966 **	0.056	0.696 **	−0.398 **	0.175 *	−0.535 **	−0.588 **	−0.046	−0.226 **	−0.083	0.191 **	−0.121
	CE%			1	−0.095	0.658 **	−0.452 **	0.184 **	−0.551 **	−0.662 **	−0.194 **	−0.281 **	−0.104	0.177 *	−0.037
	PAE%				1	−0.397 **	0.446 **	0.208 **	0.045	0.666 **	−0.095	0.573 **	−0.212 **	−0.084	−0.034
	NAE%					1	−0.658 **	0.033	−0.382 **	−0.821 **	0.362 **	−0.750 **	−0.079	−0.04	−0.262 **
Self-control scale	Total%						1	0.249 **	0.725 **	0.803 **	−0.318 **	0.634 **	0.314 **	−0.134	0.629 **
	IC%							1	0.228 **	0.171 *	−0.597 **	0.141 *	−0.477 **	−0.657 **	0.439 **
	GS%								1	0.423 **	−0.237 **	0.143 *	0.156 *	−0.448 **	0.787 **
	DC%									1	−0.141 *	0.705 **	0.012	−0.162 *	0.182 **
	SM%										1	−0.340 **	0.106	0.230 **	−0.679 **
	TI%											1	0.153 *	0.338 **	0.114
	ER%												1	0.563 **	0.113
														1	−0.401 **
															1

CE = cognitive empathy, PAE = positive affective empathy, NAE = negative affective empathy, IC = impulse control, GS = goal setting, DC = distraction control, SM = self-monitoring, TI = task initiation, ER = emotion regulation, AU = automaticity, DM = decision-making. * = $p < 0.05$, ** = $p < 0.01$.

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Article

Multisport-Integrated Training for Rugby Instructors: Success and Effects on Minirugby Players

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Abstract: Background/Objectives: The educational system thinking approach (ST) takes a holistic vision of instructors/teachers and learners' relationships, making sports pivotal for reflection on education. This study evaluated the efficacy of a multisport ST-based course on minirugby instructors' teaching competence and children players' motor conduct. Methods: The twenty-five rugby instructors (IAC) attended the 25 h course and the children of their teams (n = 109, Ch-IAC) participated in this study as experimental groups. Twenty-five rugby instructors who were not attending the course (I-CON) and their pupils (n = 111, Ch-CON) acted as control groups. Changes in instructors' teaching competence (by the Instrument for Identifying the Teaching Style and the System for Observing Fitness Instruction Time) and children's motor conduct (by the Körperkoordinationstest für Kinder test, the Game Performance Assessment Instrument, the Physical Activity Enjoyment Scale, and the physical self-efficacy scale for children) were assessed. Results: Thanks to the education received, IAC improved in didactics and methodological competence. They learned to use more production teaching styles than CON (10.5 ± 9.3% vs. 0% of the lesson time, $p < 0.05$), reduce children's inactive lesson time for management (−5.1 ± 3.3% vs. 1.1 ± 3.1%, $p < 0.05$) and promote more outside lesson topics (4.4 ± 3.2% vs. 0%, $p < 0.05$). In addition, compared to Ch-CON, Ch-IAC significantly improved motor coordination, game performance, enjoyment, and self-efficacy ($p < 0.05$). Conclusions: Children's enjoyment and self-efficacy acted as mediators that amplified the effects of the multisport training course. At the same time, the instructor's didactical and methodological competence were moderators directly favoring or worsening children's motor competence. Such an integrated multisport model is applicable and suggested for improving sports performance and education processes.

Keywords: teaching styles; teaching competence; system thinking; motor competence; sports education

1. Introduction

Sport can be assumed as a complex organism composed of a broader "systemic constellation" of parts that cannot be reductively approached by a narrow and independent

analysis of the separate elements that compose it. In this complexity of interconnections, the educational system thinking approach (ST) takes a holistic vision of the roles of instructors/teachers and learners in their own reality [1].

The term *educational system* refers to a complex web of related elements interacting with each other and representing a coherent, unique entity of youth sports. Examples of integrated and interconnected elements leading to sport and education success are (i) the reference context and the training vision; (ii) the reference legislation; (iii) the administrative sphere; (iv) the technical, pedagogical, personal, and relational skills of the instructors; (v) the children's motor and psycho-social skills.

In minirugby (the youth sector of rugby where children aged 5 to 12 learn the basics of rugby through simplified rules, reduced impacts, smaller field dimensions, and fewer players), the setting, the activities, and the social dynamics are key elements that can enhance the holistic approach based on the ST model. Each element can be structured over levels, from proximal to distal [2–4], such as follows:

- Setting: The methodological organization/structure of the minirugby program, the structure of the rugby club, and the broader structure of the community in which the club is embedded.
- Activities: Practicing the sport of interest, considering other physical/sports activities in different contexts, and engaging in complementary socio-cultural activities (school, art, music).
- Social dynamics: Within the specific sports context (instructor-child, child-child, and parent-child relationships), within complementary sports activities and group dynamics (interdependence, cohesion, identity), and within the socio-cultural sphere (external relationships with public and private entities).

A similar holistic approach was already applied in a previous study on minirugby to assess athletes and instructors' skills, didactics and relationships [5]. The ST approach must translate into positive outcomes over time in the short (having the child fun and being engaged), medium (specific skills and connections acquired should be assessed), and long term (expecting success in sports, academics, and life), hopefully guaranteeing the child's complete personal development.

Therefore, academic educational research must be precisely oriented to the concrete needs of practice and the specifics of the contexts it addresses to be truly useful in addressing the complex problems of youth sports education. This is crucial for developing effective educational policies and practices in youth sports [6]. The social reporting concept [7] implies that intervention is sustainable and justified by tangible positive results, which, in sports, are generally accounted for through successful performances, but not limited to that since recently shifted towards the educational value of sport [8], which strengthened reflection on education's methods, objectives, and outcomes.

The broader educational role of sport is particularly facilitated by capable instructors who know how to stimulate the child towards varied motor experiences to capture their attention and interest in addition to the proposal of usual specific discipline skills. This way, teaching styles are recognized as fundamental methodological elements in an instructor's professional competence [9]. Therefore, the training of sports instructors must include a strong focus on didactic-methodological skills, which are essential in educational processes and beneficial beyond sports and life in general. It is important to note that participation in a sporting activity alone does not always generate benefits [10–12].

Effective educational communication is crucial: it supports people's successful involvement in sports and physical activity. In the athlete-coach relationship, communication is the key that unlocks the development of knowledge, understanding, and sharing of goals and beliefs, reassuring both parties and building a strong foundation for success [13]. One type

of supportive communication is based on the Self-Determination Theory, founded on the three following needs necessary for educational success: (i) autonomy (i.e., the possibility to act as “actors” in one’s actions); (ii) competence (i.e., feeling effective and confident in one’s abilities, skills, and actions); (iii) relationship (i.e., feeling a sense of meaningful and reciprocal connection with others) [14]. Proper instructors’ verbal and non-verbal language, voice and paralanguage, specific organizational capacity, and psychological and personal competence represent the basics of effective and need supportive communication [14–16].

Multisport practice, as a multi-teaching approach, and improvement in instructors’ teaching skills (involving need-supportive communication skills) can represent a concrete operational translation, which, when applied, significantly enhances young people’s motivation to participate in sports. Through this integrated approach, it is possible to manipulate information and instruction about the needs of young people, thereby helping them to develop and manage their motivation for sports participation [17]. Multisport practice allows children to learn to choose autonomously and to develop various proposals practical for creating elastic motor maps that can be translated into the ability to adapt/transform the motor competence to the required needs of different situations and contexts [18].

An integrated approach, composed of multisport, multi-teaching, didactic, and organizational competence, makes it possible to orient teaching in a multi-purpose manner and target more towards the physical-motor, cognitive, or psycho-social areas, allowing flexibility of intervention adapted to the specific realities and educational needs of young people. The integrated approach plays a crucial role in managing educational interventions effectively. It ensures that teaching is targeted and efficient by minimizing downtime and periods of inactivity [19,20].

A scientific-based verification study of a methodological process of the training intervention is necessary to propose an integrated model that warrants complete didactic transferability in youth sport instructor courses [21]. Specifically, the present model, based on that by Kirkpatrick and Kirkpatrick [22], is characterized by the following phases:

1. Theoretical reference training (in this case, model-integrated and multisport information).
2. Proactive workshop formula, focusing on sharing, deciding and formulating teaching objectives, discussing these with the learners and reflecting on didactic-methodological decisions.
3. Organization of traineeships (congruent with the knowledge of the theoretical topics covered) with proposals to be formulated by teachers for their colleagues and to children from different sports categories.
4. Analysis of the effects of the training proposal on teachers’ teaching ability and of the transference that these effects present on the motor competence, enjoyment, perception of self-efficacy; amount of physical-motor commitment of the children attending the courses in which these instructors carry out their educational activities.
5. Evaluation of instructors’ satisfaction with the training course.
6. Comparison of the effects of this training with those of youth sports instructors who follow the sports federations’ standard, predominantly sport-specific and technical training.

This study aimed to evaluate and compare the effects of a multisport-integrated model training, oriented to emphasize the didactics and methodological competencies of the rugby instructors and, indirectly, on the effects (educational and sports success) of the training course on motor competence, game performance, self-perception and enjoyment in minirugby players. More specifically, this study investigated how a typology of integrated, multilateral, multi-purpose, and multisport training models for instructors can determine a direct transferability of results in terms of *body education* and *education through the body* in children attending specific sport introduction courses. We hypothesized that this training

process significantly improves teachers' teaching ability and awareness about the effects of teaching by models-integrated/multisport methodology and the teaching styles they use. It is expected that the improvement of the didactic-methodological capacity translates into evident results on a psychomotor and psychological level in the training of the youth teams entrusted to the instructors benefiting from the specific multisport education compared to those who follow a traditional single-sport training mainly of technical nature.

2. Materials and Methods

2.1. Study Design

In this study, rugby instructors were recruited to evaluate the outcomes of the multisport-integrated training program, and the children belonging to each instructor's team were involved in estimating possible changes in motor and psycho-social competencies resulting from the instructors' training process. The sample size ($n = 45$) was previously calculated with the G*Power (ver. 3.1.9.2) program using a statistical power of 95% and an effect size estimate (Cohen's d) of 0.5. For this calculation, the student t -test for unpaired data was chosen. Since 25 rugby instructors joined the multisport-integrated training program, 25 FIR rugby instructors from another rugby club were required. The statistical power resulting from this instructor sample was 0.81. Therefore, a minimum of 210 total pupils was necessary to satisfy the previously set statistical power.

2.2. Participants

A total of 50 FIR rugby instructors from teams of the Milan area and 220 children of U10 and U12 categories (the children who played in the rugby instructors' team) participated in this study (Table 1). To be included in this study, instructors had to have an FIR training license and a minimum of two years of training experience but no bachelor's degrees in sports sciences. The instructors of the experimental group must have attended at least 75% of the training program lessons. Inclusion criteria for children were attendance at a rugby course and the absence of physical (e.g., muscle-skeletal) and cognitive pathologies (e.g., cognitive disabilities) that could alter the normal procedures of tests. They also attended not less than 75% of training sessions during the experimental period.

Table 1. Participants' demographics and grouping specifics.

Participants	Variable	Experimental (IAC, Ch-IAC)	Control (CON, Ch-CON)
Instructors	N	25 (21 m, 4 f)	25 (24 m, 1 f)
	Age (y)	36.2 $\pm$ 14.4	40.0 $\pm$ 12.8
	Teaching experience (y)	5.36 $\pm$ 6.0	7.0 $\pm$ 5.0
Children	N	109 (106 m, 3 f)	111 (110 m, 1 f)
	Age (y)	9.6 $\pm$ 1.1	9.6 $\pm$ 1.0
	Weight (kg)	36.5 $\pm$ 8.3	35.4 $\pm$ 6.5
	Height (m)	1.38 $\pm$ 0.07	1.39 $\pm$ 0.07
	BMI (kg/m ²)	19.1 $\pm$ 3.6	18.2 $\pm$ 2.8

The instructors who participated in the training course and the children belonging to their respective teams composed the experimental groups (IAC = Instructors attending the course and Ch-IAC = children of the instructors attending the course); those who did not attend the training course and the respective children acted as control groups (I-CON, and Ch-CON, Instructors- and Children-Control, respectively). I-CON has not received further training in addition to that by federal specialistic rugby (i.e., the inclusion criterium).

Concerning children participating in this study, since women's rugby in Italy is a developing movement and girls usually approach this sport at a late age (after 12–14 years), the number of female minirugby players is minimal and does not represent a source of data bias. In addition, all children were at prepubertal age. Therefore, we decided not to exclude female players from this study.

2.3. Procedure

This study followed the randomized control trial model.

First, the baseline condition (pre) of instructors and children of the experimental and control groups was assessed. The instructors' initial levels of didactical and methodological competencies were determined: self-reported teaching styles and didactic interventions on their children's teams were collected, and the teaching approach while leading practice and the resulting amount of physical activity of their children were observed. In addition, motor competence, enjoyment, self-efficacy, physical activity, and play performance of the children belonging to the instructors' teams were also measured.

Over 6 months, the instructors of the experimental group (IAC) attended a multisport-integrated training and were allowed to immediately apply the newly acquired knowledge during the rugby training sessions with their respective teams (Ch-IAC). The instructors of the control group (I-CON) continued their usual training with the respective children's teams (Ch-CON). All the children were involved in a training period of 100 h per course distributed in 3 training sessions of approximately six hours per week. Therefore, in Ch-IAC, one session per week was dedicated to multisport activities and two sessions to rugby-specific activities. All three sessions of the Ch-CON were only dedicated to rugby-specific activities.

Measurements were repeated at the end of the multisport training course (post) to evaluate the outcomes on experimental instructors and respective children compared to controls, and further information about IAC satisfaction with the training attended was surveyed.

This study was approved by the ethical committee of the University of Milan.

2.4. The Multisport Instructor Training Course for IAC

The multisport instructor training course for IAC was structured as follows:

- Four meetings of 6 h and 15 min per meeting (25 h total—1 University Training Credit);
- A theoretical part in the classroom (2 h 15 min) structured with the following criterion: theory integrated with the subsequent practice of the internship (30/40 min); group work with discussions on the theoretical topics covered (15/20 min); questions from group work (a person in charge collects the requests for clarification that emerged from the previous discussion and addresses them to the trainers, 10 min); preparatory theory for the development of practical lessons (30/40 min); group work aimed at preparing internship interventions (themed lessons and methodological organization of the teaching moment, 15/20 min); questions from group work requesting further clarification on the internship (10 min);
- A practical part on the field, training with the coaches with an alternation in the roles of instructor, student, and observer (2 h);
- A practical part on the field, training with children with instructors who alternate in leading the lessons and observing (2 h).

The training process followed the main directions of the literature in its design [23,24] and was characterized by:

- Proposal to rugby instructors with previous technical-sporting experience on which to base further knowledge and teaching-training strategies, in particular through

multisport activities (basketball, ultimate, mini-volleyball, peteca, judo) valid for a specific transfer into the discipline;

- Sufficient duration of the experimentation (six months) and support to the instructors by the trainers, in the classroom and the field, to guarantee the learning and consolidation of the new skills;
- Composition of the team of trainers (scientific coordinator, teaching coordinator, researchers, doctoral students, and graduate students specially trained in administering questionnaires, motor tests, video recording, and analysis).

It was hypothesized that the model used to verify the effectiveness of the proposed educational teaching process satisfies the four key levels for the evaluation of teaching processes [22]:

1. Satisfaction of the instructors with the program received, highlighting strengths and weaknesses;
2. Learning of knowledge, with greater awareness of the educational aspects of the multisport, of the teaching styles that can be used and their effects, of the languages that can be used in communication on the field and the gym through the acquisition of an expressive, empathetic and engaging them;
3. Modification of teaching behavior during internship experiences with coaches and children (ability to use different teaching styles and more effective educational communication; improvement of one's teaching-organizational skills);
4. Final results achieved (benefits acquired by the children who follow the multisport rugby introductory courses and determined by the educational training process followed by the instructors).

The multisport-integrated model of the training course and the timeline of procedures for experimental and control groups are shown in Figures 1 and 2.

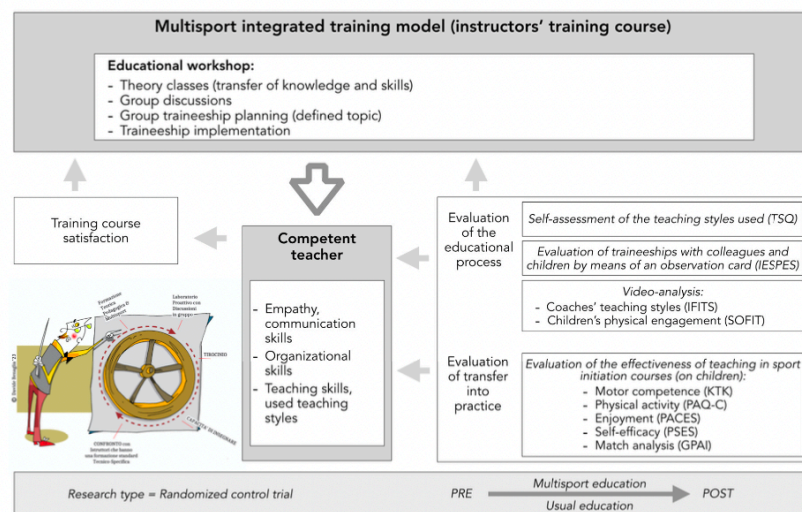


Figure 1. Framework for the methodological process of the training intervention and the investigation using a scientific approach to verify the outcomes [25].

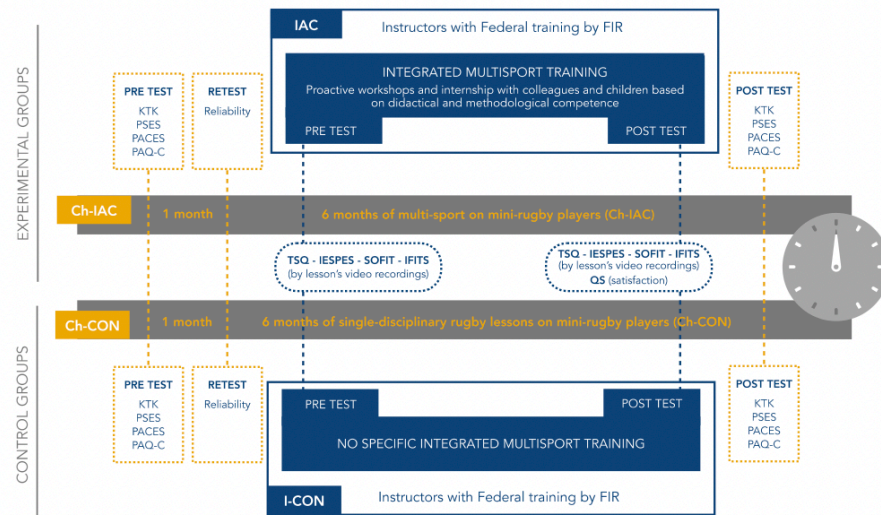


Figure 2. Timeline of the procedures followed by experimental (IAC and Ch-IAC) and control groups (I-CON and Ch-CON).

2.5. Measures

The instructors' methodological and didactic competence were assessed by the following instruments:

- Internship evaluation sheet in physical education and sports (IESPES) modified by Navickiene [26]: It is a tool designed with the aim of measuring the different didactic competencies acquired during training with real practice in the field highlighted in the application context of the internship on children or colleagues involved in the training [22,27]. A score from one to five points is attributed to communication capacity, didactics organization, and capacity of motivation and to engage the pupils [28]. The descriptors of the modified IESPES are detailed in the Appendix A;
- The teaching styles questionnaire (TSQ) [29,30]: It is designed to assess the instructors' perception of their teaching styles. It is composed of eleven items based on Mosston and Ashworth's spectrum of teaching styles scored by a 5-point Likert scale corresponding to the frequency of each style occurrence [31];
- The questionnaire of satisfaction (QS) by Kirkpatrick and Kirkpatrick [22]: It is a tool designed to measure the level of satisfaction of participants in the training course. The training program is considered satisfactory if the participating instructors are happy with it and motivated to learn. Participants' interest, attention and motivation to attend the course are indicators of the program's appreciation. The questionnaire is scored by a four-point Likert scale and includes thirteen questions. The questionnaire showed a good internal consistency equal to a Cronbach alpha value of 0.836.

Finally, some lessons were video recorded, and the Instrument for Identifying the Teaching Style (IFITS) [32] and the System for Observing Fitness Instruction Time (SOFIT) [33] were used to verify the instructors' teaching styles and the corresponding children's levels of physical commitment during the lessons. Two lessons were recorded both before and after the intervention. The IFITS video analysis evaluates the percentage of time spent by the instructors in each teaching style. The SOFIT video analysis evaluates the

percentage of time spent by children in statical, moderate to vigorous physical activity. The content of the lessons and the type of the instructors' interaction were further analyzed.

To further check the success of the multi-teaching training program and possible outcomes differentiating instructors attending the course from those acting as a control, some parameters of children composing the teams led by the instructors were analyzed. Specifically, children's level of coordination, amount of physical activity, game performance enjoyment, and perception of motor competence were assessed by the following instruments:

- Körperkoordinationstest für Kinder (KTK) [34] is a product test that measures coordination skills. The KTK consists of four items; a final score can be obtained for each test. The scores are added and converted with the reference nomograms by age and gender, returning a motor quotient indicating the level of body mastery possessed by the subject.
- The Physical Activity Questionnaire for Older Children (PAQ-C) [35] aims to determine the level of physical activity in the last 7 days, including sports, recreational activities, dancing, climbing, cycling, and unstructured activities. Low scores (from 1 to 2.33) correspond to a low level, medium scores indicate a moderate level (from 2.34 to 3.66), and high scores (from 3.67 to 5.00) imply a high level of physical activity;
- The game performance assessment instrument (GPAI) [36] aims to evaluate game performance behaviors that demonstrate tactical understanding and the player's ability to solve tactical problems by selecting and applying appropriate skills. Our study used it as the overall game performance of the whole team. To the different variables of the game (decision making, skills execution, support, game performance), judgments of appropriate/inappropriate and efficient/inefficient responses were given using percentages of total responses. A score is attributed based on an overall division between the number of appropriate versus inappropriate responses, and a score over one indicates more positive than non-positive responses. The GPAI video analyses were performed before and after the intervention.
- The Physical Activity Enjoyment Scale (PACES) [37] is a 16-item questionnaire validated for elementary school students from 12 to 16 years old. PACES scores the items answers based on a 5-point Likert scale (1: completely disagree, 2: disagree, 3: uncertain, 4: agree, 5: fully agree);
- The physical self-efficacy scale for children (PSES) [38] evaluates one's self-perception of one's physical efficiency in motor skills. This is considered a primary motivation for voluntary physical activity and sports participation. The test is scored 1–24. The higher the score, the higher the self-efficacy.

A team of Sports Science experts and doctoral students conducted all measurements during the mini-rugby course practice. The entire data collection and intervention took place over eight months. Test reliability and intra/inter-operator reliabilities were performed to ensure the validity of the analysis.

2.6. Statistical Analysis

The normality of data distribution was verified using the Shapiro–Wilk test.

The Anova 2×2 (time $\times$ group) analysis was conducted with the aim of investigating the intervention's efficacy for IESPES, KTK, and PACES. This involved examining the time effect (pre vs. post), the group effect (experimental vs. control), and the interaction (time $\times$ group) for each analysis. The intervention's efficacy for self-reported teaching styles, IFITS, SOFIT, and PSES, was investigated using delta values (post–pre) and the Mann–Whitney U test (a non-parametric version of the unpaired *t*-test) due to the violation of the normal distribution of data. For all mentioned analyses, the level of significance was set at 0.05.

As the GPAI protocol required the analysis of only four matches (two pre- and two post-intervention), the GPAI data were analyzed using a percentage comparison. In addition, a multiple regression analysis was performed to obtain information about mediators and moderators. The mediation analysis was performed following Baron and Kenny's method and was aimed at establishing mediation criteria. We considered the intervention (multisport training course) as the independent variable (IV), the main outcome (the motor competence Δ MQ norm, i.e., the delta of normalized motor quotient) as the dependent variable (DV), and the mediators (enjoyment, self-efficacy, and PAQ-C) as the variables controlling the IV-DV relationships. The mediation analysis was performed to evaluate a comprehensive measure of the effect of IV on DV and pre-post changes in the intervention group. A dummy variable was computed to differentiate the two intervention groups: 1 for the experimental group and 0 for the control group. Finally, the moderation analysis was performed to evaluate the role of a multi-teaching approach and the didactics competence of the instructors (as ModV) on children's motor competence (DV) and if they influenced the multisport training course (IV). A dummy variable of 1 was assigned for the experimental group and 0 for the control group. Concerning instructors' competence, a value of +1 was attributed to instructors' higher competence, 0 to instructors' average competence, and -1 for instructors' poor competence.

3. Results

Data describing the didactic approach of the instructors during teaching as surveyed by the IESPES (Table 2) revealed significant interactions in communication ($F = 15.837, p < 0.001, \eta^2 = 0.142$), didactics organization ($F = 4.63, p < 0.001, \eta^2 = 0.046$), motivation/personal competence ($F = 18.157, p < 0.001, \eta^2 = 0.159$), and the total score ($F = 33.896, p < 0.001, \eta^2 = 0.261$). Only IAC improved their scores in the post-intervention measurements.

Table 2. Instructors' didactic approach from the internship evaluation sheet in physical education and sports (IESPES) questionnaire.

IESPES Parameters	Time Point	IAC	I-CON
Communication	Pre	2.9 ± 0.7	3.1 ± 0.5
	Post	3.7 ± 0.4	3.0 ± 0.5
	Δ (post-pre)	0.8 ± 0.4 §	0.0 ± 0.3
Didactics organization	Pre	2.9 ± 0.7	3.0 ± 0.8
	Post	3.7 ± 0.7	3.2 ± 0.6
	Δ (post-pre)	0.8 ± 0.6 §	0.2 ± 0.5
Motivation and personal competence	Pre	2.4 ± 0.7	2.6 ± 0.7
	Post	3.6 ± 0.4	2.6 ± 0.7
	Δ (post-pre)	1.1 ± 0.6 §	0.1 ± 0.5
Total mean score	Pre	2.8 ± 0.5	2.9 ± 0.3
	Post	3.7 ± 0.3	3.0 ± 0.4
	Δ (post-pre)	0.9 ± 0.3 §	0.1 ± 0.2

Values (mean $\pm$ SD) are expressed in AU (score). IAC = instructors attending the training course; I-CON = control. Significant values: § = time $\times$ group interaction ($p < 0.05$).

The analysis of the instructors' self-reported teaching styles surveyed by the TSQ (Table 3) showed that before the training course, IAC reported having performed more multi-teaching ($p = 0.048$) and reproduction ($p = 0.016$) styles occurrences than I-CON during activity conduction. After the intervention, multi-teaching ($p < 0.001$), reproduction ($p < 0.001$), and production ($p < 0.001$) teaching styles of IAC were further different than I-CON. The deltas (post-pre) analysis between the number of reported style occurrences

further showed that IAC improved their abilities and taught with a larger number of styles, differently than I-CON, who basically unchanged their teaching approach.

Table 3. Instructors' self-reported teaching styles from the teaching styles questionnaire (TSQ).

Teaching Style	Time Point	IAC	I-CON
Multi-teaching	Pre	3.5 ± 1.2 *	2.9 ± 0.8
	Post	4.8 ± 1.3 *	2.7 ± 0.8
	Δ (post-pre)	1.3 ± 0.9 *	−0.2 ± 0.5
Reproduction	Pre	2.6 ± 0.6 *	2.2 ± 0.5
	Post	3.0 ± 0.8 *	2.2 ± 0.5
	Δ (post-pre)	0.4 ± 0.5 *	0.0 ± 0.0
Production	Pre	0.9 ± 0.9	0.6 ± 0.8
	Post	1.8 ± 1.0 *	0.4 ± 0.7
	Δ (post-pre)	0.9 ± 0.8 *	−0.2 ± 0.5

Values (mean ± SD) are expressed in N (number of reported occurrences). IAC = instructors attending the training course; I-CON = control. Significant values: * = different than I-CON ($p < 0.05$).

In the QS questionnaire administered to IAC instructors to survey their satisfaction with participation in the multisport training course, question 9 (related to the perception of children's motor skills improvement), resulted in the lower. The Friedman analysis confirmed that the items of the questionnaire of satisfaction significantly scored differently ($p < 0.001$). However, the post hoc highlighted that only question 9 significantly differed from several other questions, as reported in Figure 3.

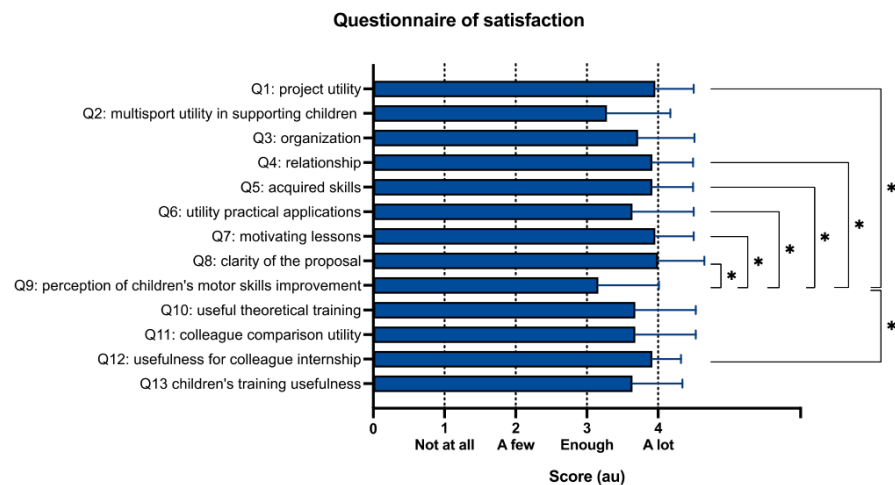


Figure 3. Results of the questionnaire of satisfaction (QS). In the survey, scores from 1 to 4 were assigned based on the level of satisfaction (1—not at all, 2—a few, 3—enough, 4—a lot). Significant difference: * = $p < 0.001$.

The instructors' self-reporting of the teaching styles surveyed by the TSQ was implemented by observing and analyzing some lessons by the IFITS (Table 4). The analysis showed a significant difference in pre-intervention practice teaching styles ($p = 0.038$), while in post-intervention, significant differences were detected in command ($p = 0.01$), practice

($p < 0.001$), inclusion ($p < 0.001$), guided discovery ($p = 0.010$), management ($p = 0.03$), and production ($p = 0.010$).

Table 4. Percentages of teaching styles used by the instructors as assessed by the Instrument for Identifying the Teaching Style (IFITS).

Teaching Style	Time Point	IAC	I-CON
Command	Pre	23.3 ± 21.9	4.9 ± 8.8
	Post	39.4 ± 13.6 *	8.8 ± 15.8
	Δ (post–pre)	16.0 ± 27.6	3.9 ± 13.2
Practice	Pre	37.6 ± 28.0 *	62.2 ± 24.6
	Post	20.0 ± 10.0 *	59.5 ± 21.2
	Δ (post–pre)	−17.0 ± 32.7	−2.7 ± 13.4
Reciprocal	Pre	N/U	N/U
	Post	3.5 ± 6.9	N/U
	Δ (post–pre)	3.5 ± 6.9	N/A
Self-check	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post–pre)	N/A	N/A
Inclusion	Pre	N/U	N/U
	Post	8.2 ± 1.8 *	N/U
	Δ (post–pre)	8.2 ± 1.8 *	N/A
Guided discovery	Pre	N/U	N/U
	Post	10.5 ± 9.3 *	N/U
	Δ (post–pre)	10.5 ± 9.3 *	N/A
Convergent discovery	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post–pre)	N/A	N/A
Going beyond	Pre	N/U	N/U
	Post	N/U	N/U
	Δ (post–pre)	N/A	N/A
Management	Pre	39.1 ± 11.3	32.9 ± 21.7
	Post	19.4 ± 10.4 *	31.7 ± 7.9
	Δ (post–pre)	−19.7 ± 17.3 *	−1.2 ± 17.3
Total Reproduction	Pre	60.9 ± 11.3	67.1 ± 21.7
	Post	70.9 ± 8.3	68.3 ± 7.9
	Δ (post–pre)	10.1 ± 15.7	1.2 ± 17.3
Total Production	Pre	N/U	N/U
	Post	10.5 ± 9.3 *	N/U
	Δ (post–pre)	10.5 ± 9.3 *	N/A

Values (mean ± SD) are expressed in percentage of the lesson total time (%). IAC = instructors attending the training course; I-CON = control. N/U = not used. N/A = not applicable. Significant values: * = different than I-CON ($p < 0.05$).

The physical commitment of the children depending on how the instructors conducted the lessons, as reported by the SOFIT analysis (Table 5), was similar in Ch-IAC and Ch-CON, confirming that there was no difference between IAC and I-CON conduction before IAC training. Conversely, after the training, IAC instructors improved their conduction: compared to I-CON, children belonging to IAC teams spent less time standing ($p = 0.043$), benefited from lessons having less management ($p < 0.001$), reduced fitness ($p = 0.023$), and more game ($p = 0.017$) contents, and received more lessons outside topics ($p < 0.001$).

Table 5. Children's physical commitment during the lessons due to the instructors' conduction, as from the System for Observing Fitness Instruction Time (SOFIT) analysis.

Children's Commitment		Time Point	IAC	I-CON
Children's activity	Lay	Pre	1.2 ± 2.6	0.3 ± 0.9
		Post	0.9 ± 1.4	0.4 ± 0.8
		Δ (post-pre)	−0.3 ± 3.3	0.1 ± 1.3
	Seated	Pre	3.1 ± 4.6	2.5 ± 3.6
		Post	4.3 ± 3.3	3.7 ± 3.0
		Δ (post-pre)	1.2 ± 4.4	1.2 ± 4.5
	Stand	Pre	33.6 ± 16.3	26.6 ± 14.4
		Post	11.2 ± 5.6 *	20.2 ± 12.3
		Δ (post-pre)	−22.4 ± 20.4	−6.4 ± 22.9
	Moderate	Pre	25.1 ± 11.9	28.5 ± 11.6
		Post	34.8 ± 9.0	31.2 ± 11.1
		Δ (post-pre)	9.7 ± 15.1	2.8 ± 18.2
	Vigorous	Pre	37.0 ± 14.1	43.2 ± 12.2
		Post	48.8 ± 10.2	44.4 ± 12.8
		Δ (post-pre)	11.9 ± 21.0	1.3 ± 18.7
Lesson content	Management	Pre	7.8 ± 3.6	6.4 ± 2.7
		Post	2.6 ± 1.0 *	7.5 ± 1.8
		Δ (post-pre)	−5.1 ± 3.3 *	1.1 ± 3.1
	Knowledge	Pre	21.6 ± 9.0	21.2 ± 11.0
		Post	23.0 ± 7.1	17.9 ± 17.4
		Δ (post-pre)	1.4 ± 12.8	−3.3 ± 20.9
	Fitness	Pre	13.6 ± 19.2	19.7 ± 21.0
		Post	2.1 ± 4.0 *	12.1 ± 9.4
		Δ (post-pre)	−11.6 ± 18.0	−7.6 ± 18.8
	Skills	Pre	44.7 ± 26.2	39.7 ± 28.4
		Post	40.5 ± 12.5	31.4 ± 20.9
		Δ (post-pre)	−4.2 ± 28.6	−8.3 ± 30.1
	Game	Pre	11.9 ± 15.7	13.0 ± 17.9
		Post	31.8 ± 11.4 *	31.2 ± 32.9
		Δ (post-pre)	19.9 ± 16.5	18.2 ± 30.1
Coaches' interaction	Inside lesson topics	Pre	38.5 ± 12.5	33.0 ± 12.4
		Post	42.1 ± 11.8	38.0 ± 13.4
		Δ (post-pre)	3.6 ± 11.4	5.1 ± 9.4
	Outside lesson topics	Pre	0.0 ± 0.0	0.0 ± 0.0
		Post	4.4 ± 3.2 *	0.0 ± 0.0
		Δ (post-pre)	4.4 ± 3.2	0.0 ± 0.0
	No interaction	Pre	61.3 ± 12.2	67.0 ± 12.4
		Post	54.6 ± 14.5	62.1 ± 13.3
		Δ (post-pre)	−6.8 ± 13.0	−5.0 ± 9.3

Values (mean ± SD) are expressed in percentage of the lesson total time (%). IAC = instructors attending the training course; I-CON = control. Significant values: * = different than I-CON ($p < 0.05$).

The children's testing sessions showed that Ch-IAC (i.e., the children of the teams of the instructors who attended the training course) outperformed Ch-CON in several parameters. In coordination skills, a significant interaction (time × group) was retrieved in the normalized motor quotient of the KTK ($F = 23.549$, $p < 0.001$, $\eta^2 = 0.056$), indicating that Ch-IAC had a higher normalized motor quotient than Ch-CON in the post-test (Figure 4, panel A). Similarly, Ch-IAC also enjoyed the activity more than Ch-CON: a significant

interaction (time $\times$ group) of PACES questionnaire total score ($F = 94.463$, $p < 0.001$, $\eta^2 = 0.193$) was retrieved (Figure 4, panel B).

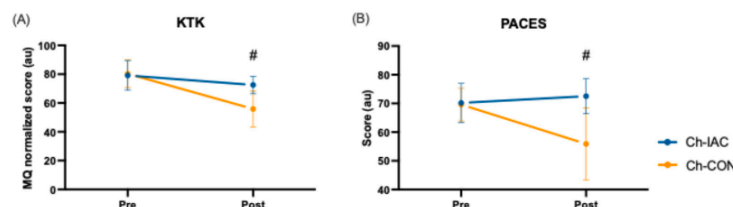


Figure 4. Time $\times$ group interactions in children's motor skills and enjoyment of physical activity. (A) KTK (Körperkoordinationstest für Kinder) motor quotient; (B) PACES (Physical Activity Enjoyment Scale) total score. MQ = motor quotient; Ch-IAC = children from teams of instructors attending the training course; Ch-CON = children of the instructors' control group. # = significant time $\times$ group interaction ($p < 0.001$).

Instructors' participation in the training course considerably affected children's self-efficacy and physical activity levels. The analysis of delta values (post-pre) of PSES (Figure 5, panel A) showed that Ch-IAC positively increased self-efficacy compared to Ch-CON, which lowered ($p < 0.001$). Similarly, PAQ-C delta analysis (Figure 5, panel B) showed higher positive changes in Ch-IAC physical activity levels than Ch-CON ($p < 0.001$).

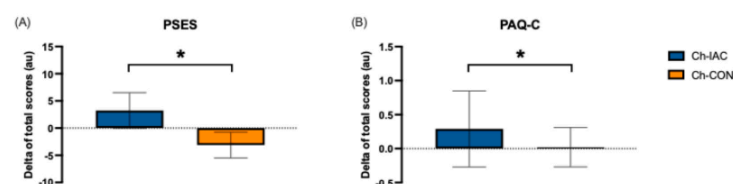


Figure 5. Children's self-efficacy and physical activity level variations (delta = post-pre values). (A) PSES (physical self-efficacy scale for children) delta scores; (B) PAQ-C (Physical Activity Questionnaire for Older Children) delta scores. Ch-IAC = children from teams of instructors attending the training course; Ch-CON = children of instructors' control group. * = $p < 0.001$.

The match analysis through the GPAI instrument (Figure 6) showed an increase in Ch-IAC efficient skill execution and, consequently, in general match performance. No changes were detected between pre- and post-intervention decision-making.



Figure 6. Match analysis results by the game performance assessment instrument (GPAI) related to decision making (A), skill execution (B), and performance (C). Significant differences by the Chi-squared analysis are reported.

Mediation and Moderation Analysis

Figure 7 depicts the effects of enjoyment and self-efficacy as mediators in the relationship between independent (multisport-integrated training course) and dependent (motor competence) variables. The multisport-integrated training course had a significant effect on motor competence (c: $E = 7.019$, $p = 0.002$) and enjoyment (a: $E = 16.565$, $p < 0.001$). A significant effect of enjoyment on motor competence was found (b: $E = 0.184$, $p = 0.016$). The MeE, revealed that the indirect effect (a + b) of enjoyment is significant (a + b: $E = 3.04$, $p < 0.0019$), so the enjoyment mediates the effect of the intervention on motor competence. In the MeE, a significant total effect was detected ($E = 10.06$; $p < 0.001$). As in MeE, the direct effect (even if significant) resulted lower than the total effect; it is possible to notice that enjoyment partially mediates the effect of the intervention on motor competence.

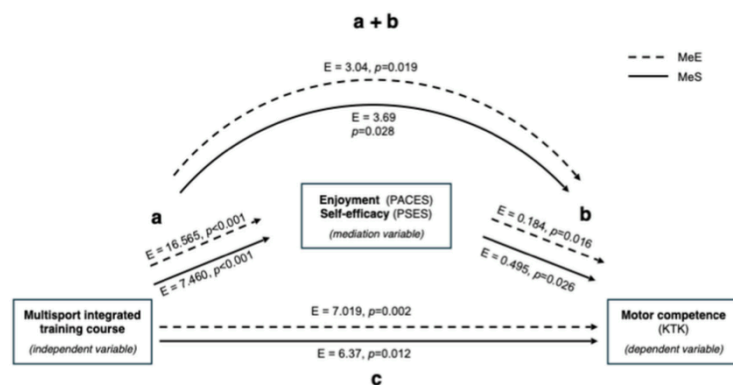


Figure 7. Flow chart of the mediation analysis. MeE = enjoyment mediation; MeS = self-efficacy mediation. a = effect of the independent on the mediation variable; b = effect of the mediation on the dependent variable; c = effect of the independent on the dependent variable (direct effect); a + b = effect of the independent on the dependent variable mediated by the mediation variable (indirect effect).

The self-efficacy mediation analysis (MeS) revealed that intervention had a significant effect on motor competence (c: $E = 6.37$, $p = 0.012$) and Self-efficacy (a: $E = 7.460$, $p < 0.001$). A significant effect of self-efficacy on motor competence was found (b: $E = 0.495$, $p = 0.026$). The MeS, revealed that the indirect effect (a + b) of self-efficacy is significant (a + b: $E = 3.69$, $p < 0.0028$), so the self-efficacy mediates the effect of the intervention on motor competence. In the MeS, a significant total effect was detected ($E = 10.06$; $p < 0.001$). As in MeS, the direct effect (even if significant) resulted lower than the total effect; similarly to MeE, it is possible to notice that self-efficacy partially mediates the effect of the intervention on motor competence.

The PAQ-C mediation analysis (MeP) revealed that intervention had a significant effect on motor competence (c: $E = 9.66$, $p < 0.001$) and PAQ-C (a: $E = 0.317$, $p < 0.001$). No significant effect of PAQ-C on motor competence was found (b: $E = 1.28$, $p = 0.553$). In the MeP, a significant total effect was detected ($E = 10.06$; $p < 0.001$). The MeP, revealed that the indirect effect (a + b) of PAQ-C is not significant (a + b: $E = 0.405$, $p = 0.556$), so the amount of physical activity does not mediate the effect of the intervention on motor competence.

The moderation analysis (Figure 8) of didactical competencies (MoD) showed that a single multisport training course alone could not fully explain the DV results ($E = 1.65$, $p = 0.324$). Indeed, high didactics competence of instructors (Hi) positively influences

the motor competence in children ($E = 8.05$, $p = 0.002$), an average instructor's didactics competence (Av) brought a little but not significant improvement in motor competence ($E = 1.65$, $p = 0.324$), and a poor or just sufficient instructors' competence in didactics (Lo) might lead to an aggravation of motor competence (Lo: $E = -4.76$, $p = 0.053$; Av: $E = -9.06$, $p < 0.001$). Furthermore, the MoD interaction's effect shows that, for every increase in units in methodological competence, the effect of the intervention becomes more positive of 11.11 units ($E = 11.11$, $p < 0.001$).

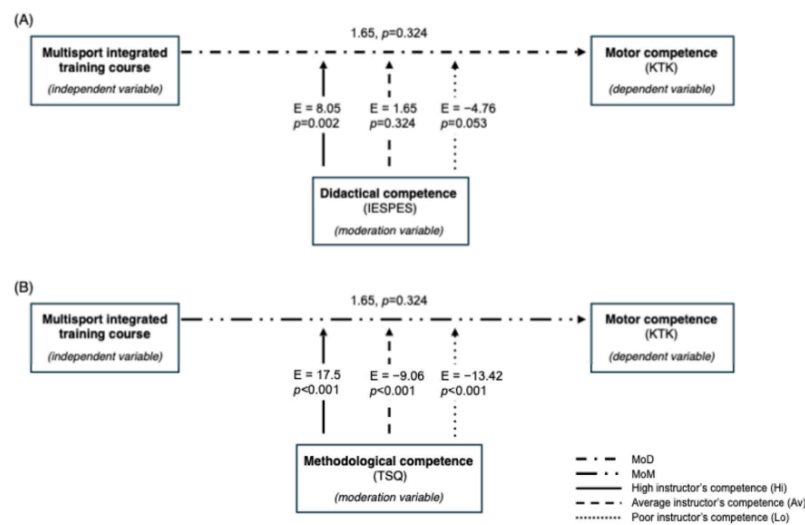


Figure 8. Flow chart of the moderation analysis of the role of didactical competence (A) and methodological competence (B). MoD = didactical competence moderation; MoM = methodological competence moderation. In (A), the moderation analysis of the role of didactical competence (MoD) is shown., the full line refers to a high instructors' competence (Hi), the double-dashed line to an average instructor's (Av) competence and the dotted line to a poor instructor's competence (Lo).

About MoM, the higher the instructor competence (Hi), the higher the motor competence ($E = 17.5$, $p = 0.001$). Moreover, the MoM interaction's effect shows that, for every increase in units in methodological competence, the effect of the intervention becomes more positive of 5.94 units ($E = 5.94$, $p = 0.057$). Hence, as the number of teaching styles used increases, it partially moderates the effect of intervention.

4. Discussion

The primary aim of this study was to investigate the effects of multisport-integrated model training, which a sample of rugby instructors (IAC) participated in. Thanks to training, IAC instructors significantly improved their didactic and methodological competencies, as evaluated through the internship evaluation sheet in physical education and sports (IESPES), the Instrument for Identifying the Teaching Style (IFITS), and the self-report referring to the Teaching Style Questionnaire (TSQ).

In the integrative multisport model we presented, educational and sports success are strictly related and depend on instructors' competence. Figure 9 graphically depicts the multisport-integrated model and how educational and sports success are considered part of the same system. In educational and sports success, autonomy, competence, and

relationship are the keys to supportive communication based on a pupil-centered approach. Teaching styles are related to autonomy (production styles centered on pupil), competence (reproduction styles centered on motor competencies), and relationship (multi-teaching based both on education in sport and through sport with adaptation to the needs of children). Autonomy, general competence, and relationships help build the children's psychological aspects (such as self-efficacy and enjoyment) and motor competence. A competent instructor based on methodological competence (teaching styles) and didactics competence (elements aimed to need supportive communication: communication capacity, motivation capacity, and didactic organization) is the core of this integrated multisport system.

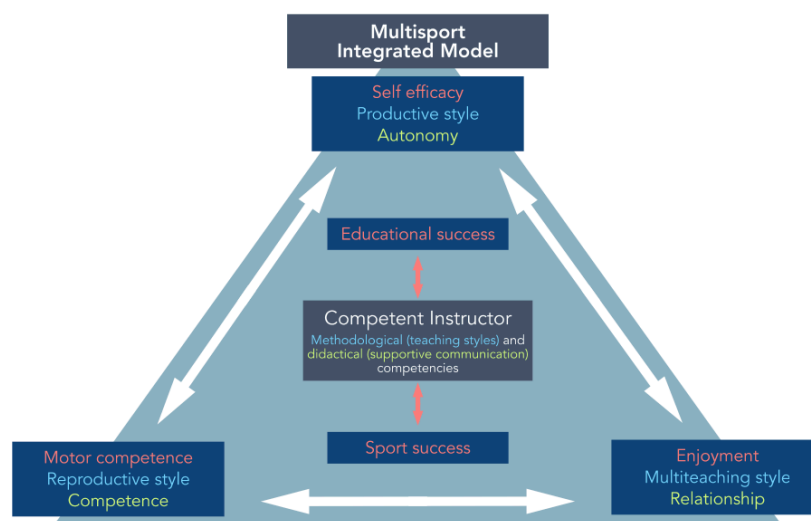


Figure 9. The framework of the integrative multisport model: educational and sports success is strictly related to the key elements characterizing the need supportive communication integrated with the utilization of different teaching styles (autonomy, competence, and relationship). Both instructors and children are related to these key elements.

Based on the results of the IESPES instrument evaluating the internship's success, IAC improved total score, communication skills, didactics organization, motivation, and personal competence. These findings agree with Kirkpatrick [22], who found that proposing an adequate training course, alternating theoretical topics, debates, and internships with instructors and children could enhance instructors' didactic and methodological competence.

The self-reported teaching styles questionnaire showed that the IAC instructors used many more different teaching styles at the end of the multisport training course. Despite the frequent use of reproduction styles (70.9%), thanks to the training course, they learned to use production styles, such as those suggested by Da Silva, for team-oriented sports because helping children develop decision-making and playing skills [39–41]. Instructors improved their overall methodological competence by learning to manage the integration of reproduction and production teaching styles with the multi-teaching approach.

The use of an integrated multisport approach combined with methodological and didactical competence (as we considered through the statistical analysis of moderators) could improve socio-psychological aspects and self-awareness in children because it

helps them develop autonomy, motor competence, and relationships with the pairs and adults [14,42,43].

The SOFIT's results about the conduction of physical activity performed by the pupils trained by IAC found a significant reduction in the children's time standing still (from 33.6% to 11.2% of the total lesson time) spent in the instructors' management (from 7.8% to 2.6%) and fitness (from 13.6% to 2.1%), and a significant increase in instructors' promotion of outside physical activity (from 0% to 4.4%). The decrease in the time spent standing still and in management presumably highlights that children were more involved in physical activity and, therefore, that IAC instructors found other strategies to manage the children, such as sitting during explanations (as the increase in time spent sitting evidence). Indeed, the sitting posture allows for a minor possibility of uncontrolled movement of pupils, generating less problematic and dispersive situations during group management, with fewer organizational difficulties, as the reduction in management time retrieved by both SOFIT (−5.1%) and IFITS (−19.7%) analysis confirms. The decrease in the time spent on fitness (−11.6%) can be compensated by an increase in time spent on games (19.9%). According to Feigenbaum [44], children of this age should become fit and conditioned through different proposals, not only aimed at mere physical fitness but also through games that are more motivating proposals than mere exercises that make them highly involved and adequately conditioned. General conditioning by games could result in a lower perception of fatigue and higher motor control. These data, according to GPAI outcomes for execution skills and game performance, showed a possible improvement in IAC after the multisport training course because the more fitness (acquired by general games), the more precision in specific skills and effective performance. The integration of motor control in conditioning through games is the most effective way to reach a positive effect in situational sports performance due to an immediate transfer. Instructors also increased the promotion of outside activity (which was highlighted by the previous analysis with SOFIT) thanks to the multisport training course, as the increment of PAQ-C values of Ch-IAC confirms. These results demonstrate how a multisport-integrated approach contributes to the development of healthy lifestyles and public health and, therefore, to educational success based on physical literacy [45].

When addressing the effects of the multisport training of IAC on children's outcomes, this study's results evidenced significant differences in motor competence and game performance in favor of Ch-IAC compared to Ch-CON. The multisport-integrated approach positively influenced the motor coordination of children taught by IAC instructors, possibly because they proposed different types of activities and stimuli than I-CON, making the children more coordinated and motor competent. According to the literature, children who are stimulated to try different kinds of basic sports skills and activities are better supported in continuing motor and sports practice as they overcome the proficiency barrier [46–48]. As previously highlighted, considering the PAQ-C results, the multisport-integrated approach can increase the children's amount of physical activity as instructors increase the promotion of sports practice and the subsequent children's knowledge and the chance to choose additional sports activities in their free time [49,50]. Children who are not stimulated to vary motor skills and sports activities might not be able to acquire sufficient fitness at later ages. Therefore, the results of the present study represent a valuable indicator of how such an approach based on multisport-integrated practice can positively impact the well-being and health of the children's future [51–53].

The positive outcomes of PACES of Ch-IAC show that children enjoyed the multisport activities proposed and were involved in activities with different proposals that suit them best. The increase in PSES score Ch-IAC also demonstrates that the possibility to try different sports and learn different skills enhanced children's self-efficacy [18,54–56].

Furthermore, given the positive outcomes from the instructors' questionnaire of satisfaction analysis, this educational training program results in a solid platform for sports and educational success. Considering this, instructors and sports societies should align their interventions with these findings [22].

The mediation and moderation analysis further investigated the effectiveness and transferability of the multisport-integrated training course on children. The results emerging from the mediation analysis showed that enjoyment and self-efficacy partially mediate the effect of the multisport intervention on motor competence, so they partially could amplify the effects on motor competence in children [18,54]. The moderation analysis showed that different levels of didactical and methodological competence can improve or aggravate motor competence in children. The more the instructors' didactical and methodological competence, the more the children's motor competence; the less didactical and methodological competence the instructors have, the less the children's motor competence. For this purpose, the use of a need supportive communication integrated with motivational, personal, and organizational competence (didactical approach) and a multi-teaching approach (methodological competence) might improve the children's motor competence [14,42,50].

Using a multi-teaching style and active reflection approach, stimulated above all by greater use of productive styles based on question-delving into the "why" and "how" of human movement, is a way to encourage non-linear pedagogies. This way, it has been possible to administer a varied and non-linear approach by modifying task, environmental, or organismic constraints, therefore not addressing what to do (as often authors claim in literature) but how to do it (increasing a diversified teaching styles approach), which ended in more significant effects on learning in the experimental group (Ch-IAC) compared to the control group [50]. The nonlinearity of learning processes must be interpreted holistically, considering not only the individual and the effects that a proposal could determine on the different personal areas but also the group in which the individual is inserted and the context that could determine the necessity of finding new ways to offering sports experiences in relation to the children's needs [57]. Based on nonlinear pedagogy, a multisport approach stimulates variants integrated with the methodological ones related to teaching styles.

The literature evidenced how the acritical use of sports activities, caused by the implicit selectivity of the sport, is incompatible with an active long lifestyle [58,59]. Also, a multisport interpretation, as a summary of different sports disciplines, not mediated by reflective practice and not contextualized, could lead to an excess of competition, which results in one of the most common causes of dropouts in youth [60,61]. Young athletes must be stimulated to reflect on their limits or competence, act reflectively, and self-check their practice through questions to avoid and prevent this problem.

Further consideration arises concerning the relationship between a nonlinear approach based on methodological competence (multi-teaching style practice) and the instructors' didactic competence related to supportive communication and organization of contents competence [62]. The notable relationship that emerged demonstrates how methodological and didactic competence are strictly related. The instructors' skills in varying teaching and sports approaches further let them acquire a better competence in supportive communication, organizational aspects of didactics, and lesson management. Using a nonlinear pedagogy by varying proposals through multisport and multi-teaching approaches and reflective practice (as presented in the training course that has been the object of the present study) can stimulate pupil-centered teaching with the aim to generate a children's task-oriented motivational climate essential to acquire adequate motor skills [50,63,64]. Furthermore, a multi-teaching approach might favor the use of need-supportive communication and didactics organization through educational experiences that satisfy children's

psychological needs (autonomy, competence, relationship) necessary to lead to sports and educational success [14].

Regarding Vigotskij's zones of proximal development [65], adapting teaching styles and communication methods to find the proper stimulation through a holistic perspective does not mean forgetting the technical aspects of the discipline but intentionally inserting them in the didactic-methodological approach to guarantee a more efficient acquisition.

Educational didactics in sports, long-lived and sustainable, do not focus on performance but must apply the different levels of motor competence through methodological and didactic strategies to embrace children's rights [66,67] and guarantee continuity of practice at group and sports club levels [68,69]. Long-life sports practice is essential and should include inclusive didactics oriented to a progressive consciousness related to one's limits of competence and possible improvements, representing a concrete pillar of youth life and physical activity habits [53]. From this perspective, to move from an interpretation of sports disciplines as an objective to an interpretation aimed at educational purposes, training instructors' courses aimed at modifying the mentality, approaches, methods and teaching methods with which sports practice is traditionally proposed at a youth level becomes indispensable. The success of a youth instructor should not be evaluated through the performance obtained by children but in avoiding dropouts and promoting future continuity of individual practice by stimulating motivation to play sports in the current discipline or others.

Instructors' and children's systems are on the same plan and converge into a unique model, according to the system thinking approach (Figure 10), in which leverage, and resistance points can be individuated. Leverage points for both instructors and children are autonomy (self-reported teaching styles used and self-efficacy, respectively), competence (methodological and didactics competence, and motor competence, respectively), and relationship (questionnaire of satisfaction and enjoyment, respectively) [70]. Resistance points can be the relationship between instructors and children and the actual vision of several Italian sports societies, which consider sports and educational success as detached systems, with the primary importance addressed to performance [70]. This model integrates instructors' and children's plans, builds a relationship based on a need for supportive communication and the vision of sports and educational success as attached parts and fundamental bases for constructing instructors and athletes of every category from childhood to adulthood.

Limits of This Study

In this study, the multisport model was limited to instructors interacting in a youth sports contest, not accounting for relationships with high-performance or amateur sports aimed at the well-being promotion of later ages. The model did not fully account for the possible conflicts that could emerge in the actual situation by converging the subsystems of competitive sport (ego-oriented, selective, and often considered primary in Italian reality) and educational sport (task-oriented based on an inclusion system). The conflicts between the two contrasting situations could generate an imbalance challenging to overcome in sports clubs [71].

The model also concerns the specific reality of rugby that cannot be generalized in other contests and sports disciplines. Based on the outcomes of this initial study, we can assert that the project's structure has the potential to shape our understanding of sports and sports associations in formative and educational terms. Notably, a multisport activity has been found to significantly enhance the children's motor competence and play capacity, leading to higher sporting success.

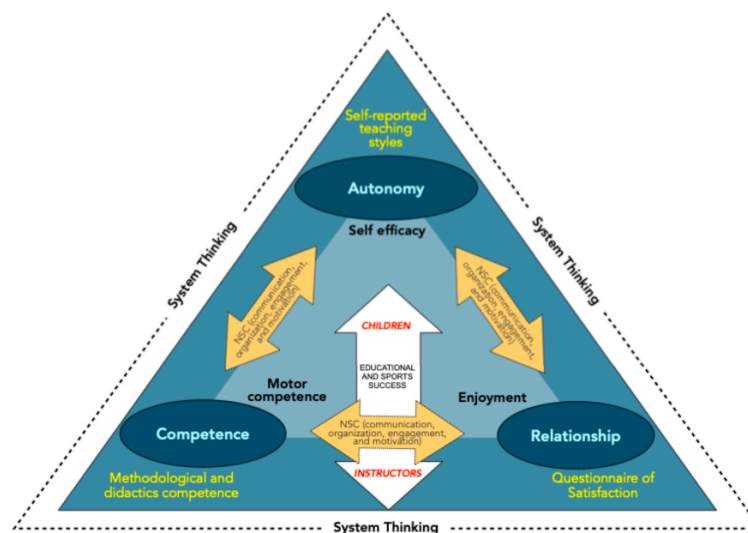


Figure 10. Conceptual model of the instructor-children system of the multisport-integrated training approach and its investigation. The two triangles represent the instructors' (blue) and children's (light blue) systems. The fundamental topics of the need for supportive communication are shown at the vertexes. For every dimension (autonomy, competence, and relationship), this study assessed instructors' perception of the teaching styles used, methodological and didactic competence, and appreciation for the training course (yellow text). For the same dimensions, the children's self-efficacy, motor competence, and enjoyment were measured (black text). The children-instructor relationship is the basis of educational and sports success. NSC = need supportive communication.

5. Conclusions

The rugby instructors attending a multisport-integrated training course considerably improved their didactic and methodologic competencies in conducting the sports activity with their pupils. The success of the multisport model (Figure 10) can be ascribed to having integrated the children's and instructors' domains related to the autonomy, competence, and relationship dimensions according to supportive communication, which, under the system thinking perspective, considers interconnections among setting, activity, and social dynamics variables of the minirugby environment. Participation, individual competence and performance of both instructors and minirugby players were favored by the multisport-integrated training.

The future development of this type of research is represented by longitudinal studies extended to different sports disciplines and social realities, which can, in the long term, collect data/observations for comparisons between different environmental and cultural contexts.

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P.L.I., D.C. (Dario Colella) and G.M.; supervision, P.L.I. and D.C. (Domenico Cherubini). All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of University of Milan, Italy (number 14/24, 13 February 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The data supporting the main findings of this study are available on reasonable request with access granted to researchers meeting the criteria for access to confidential data. The data repository is Zenodo, at <https://doi.org/10.5281/zenodo.13999101> (URL accessed on 27 October 2024).

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. IESPES Items' Descriptors

Items	Descriptors ¹
Verbal communication	Comprehension; logic; choice of words of appreciation; choice of words of reproach; use of metaphors/narration.
Voice and paralanguage	Volume; Timbre; Modulation; expository rhythm; use of silences and pauses.
Non-verbal communication	Facial expression; eye gaze; eye contact; posture; proxemics gestures.
Specific didactics	Choice of exercises; progression; demonstration; correction; adaptation of the proposal.
Elements of organizational references	Location of tools; location in space of learners; safety/prevention/assistance rules; use of conceptual diagrams/charts/illustrations; time management (activity times; question times; organizational times).
Psychological references	Interest aroused; emulation level; expectations/requests; reinforcement; contextualization.
Personal competence	Charisma; accuracy; confidence; empathy; self-monitoring

¹ Instructors were evaluated on the five descriptors for each item. The descriptors were scored as 0 (=inadequate) or 1 (=adequate) point, returning a score ranging from 0 and 5 for each item. The final score was calculated as the mean of all item's scores.

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ANNEX 5. Acceptance by the co-authors for the doctoral student to submit the scientific articles as part of her doctoral thesis and renunciation by the co-authors to submit them as part of another doctoral thesis.



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Fdo.:

A handwritten signature in black ink, consisting of stylized, overlapping loops and a long horizontal stroke extending to the right.



ACEPTACIÓN DE LOS COAUTORES

D. Gabriele Signorini como coautor de los trabajos y publicaciones científicas que se detallan en el presente informe, aceptan que formen parte de la Tesis Doctoral realizada por D. Marta Rigon en el Departamento de Ciencias de la Actividad Física y del Deporte de la Universidad Católica San Antonio de Murcia

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RENUNCIA DE LOS COAUTORES NO DOCTORES

D. Gabriele Signorni como coautores de los trabajos y publicaciones científicas que se detallan en la presente informe, renuncian a que los mismos formen parte de otra Tesis Doctoral diferente a la realizada por D. Marta Rigon. en el Departamento de Ciencias de la Actividad Física y del Deporte de la Universidad Católica San Antonio de Murcia

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