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**Toward a Bio-Psycho-Social Understanding of Social and Emotional Skills
Development in Primary and Middle Schools**

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To those who accompanied me on this journey.

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Summary

Social and Emotional Skills (SES) constitute a fundamental dimension of child and adolescent development. They enable children to recognize and regulate their emotions, establish and maintain relationships, and successfully engage in the learning process. Far from being “extra” competencies, SES are now widely considered a core foundation for academic achievement and lifelong well-being (Denham et al., 2012; Jones et al., 2015; Sorrenti et al., 2025; Taylor et al., 2017). Evidence shows that strong socio-emotional competences in childhood predict higher educational attainment, better mental health, more stable employment, and civic engagement in adulthood (Moffitt et al., 2011; OECD, 2023). As Immordino-Yang and Damasio (2007) noted, *we feel; therefore, we learn*. Without emotional safety, regulation, and connection, learning itself cannot fully take place. Schools, hence, emerge as a crucial arena for SES promotion, particularly in early and middle childhood, when developmental plasticity is high and pedagogical scaffolding can have a long-term impact.

To capture the complexity of SES development, this dissertation adopts a biopsychosocial perspective (Engel, 1977; Bronfenbrenner, 1979; Sameroff, 2010). SES are not innate traits that unfold in isolation, but a dynamic capacity that emerges from the interplay between biology, environment, and professional practices. At the biological level, we decided – among the various alternatives – to examine cardiac vagal tone as a psychophysiological marker of self-regulation and adaptive emotional functioning (Porges, 2007; Thayer & Lane, 2009). At the environmental level, the focus was on the classroom climate as perceived by students, and on cooperative learning as an instructional practice rooted in Social Interdependence Theory (Johnson & Johnson, 2009). Finally, at the professional level, the work explored teachers’ well-being (Jennings & Greenberg, 2009; Oberle et al., 2016), considered an essential but often underestimated driver of socio-emotional growth in schools.

Specifically, the first chapters provide the conceptual and methodological background for this work. Chapter 1 introduces the construct of SES, highlighting their protective role across development and the pivotal contribution of schools as a primary arena for their promotion. It also

discusses the challenges related to their conceptualization and assessment, pointing to the need for multi-method approaches to capture their complexity. Chapter 2 develops the theoretical framework of the dissertation, presenting the biopsychosocial model of SES and focusing on both biological characteristics (with a particular emphasis on cardiac vagal tone) and environmental ones (such as classroom climate and teacher-related factors). Chapter 3 examines cooperative learning as a structured and empirically supported pedagogical practice for fostering SES, also considering the added value of technological supports. Finally, Chapter 4 introduces the overarching aims and design of the PhD project, outlining how the empirical studies test the interplay between these factors within real school settings.

The empirical chapters examine these factors through a series of interconnected studies. Chapter 5 analyzed the interaction between CVT and students' perception of classroom climate in predicting SES. Results revealed that CVT alone was not sufficient to account for differences in socio-emotional competencies; instead, it functioned as a moderator, amplifying the benefits of supportive classroom environments for children with higher vagal regulation, while students with lower CVT were less responsive to positive contexts. Chapters 6 and 7 investigated the role of cooperative learning through two large-scale studies conducted in Italian primary and middle schools. The use of a tech-supported CL intervention (PeerLearning.net) provided evidence that structured peer collaboration enhances both cooperative behavior (Chapter 6) and socio-emotional outcomes such as emotional knowledge, social awareness, and relationship skills (Chapter 7). Chapter 8 shifted attention to teachers, presenting data from a national sample that revealed high levels of stress and burnout among Italian educators. These findings underscore the importance of supporting teachers' well-being, as emotionally strained professionals are less capable of maintaining the socio-emotional climate necessary for student development.

Taken together, the results of this dissertation underscore that SES development is not reducible to either biological predispositions or environmental influences alone. Instead, it emerges from the transactional interplay of multiple systems, consistent with developmental models that

emphasize reciprocal and dynamic processes (Sameroff, 2010). Some overarching conclusions can be drawn. First, biological sensitivity, as indexed by CVT, affects how children benefit from classroom environments, suggesting that interventions should be tailored to children with lower self-regulation. Second, classroom climate should always be safe and nurturing, considering its direct effect on SES development. Third, cooperative learning, when implemented with fidelity and supported by digital tools, represents a robust and scalable pedagogical method for embedding SES into daily instruction. Fourth, a multi-method approach should be used to assess SES at school, thereby better capturing those skills during this age period and avoiding biases and measurement issues. Finally, teachers' well-being is not a peripheral element but a central determinant of whether schools can effectively foster SES, and, thus, should be explored in its direct effects on socioemotional skills development.

In conclusion, this dissertation contributes to a biopsychosocial understanding of SES development in school contexts, offering insights that are directly relevant for educators, stakeholders, and policymakers. Promoting SES requires systemic investment not only in effective classroom practices but also in the professional and emotional resources of teachers. Only by aligning biological, environmental, and institutional supports can schools become spaces that prepare students not just for academic success but for the social and emotional demands of life.

Chapter I | Social and Emotional Skills

1.1 Social and Emotional Skills in Primary and Middle Schools

Social and Emotional Skills (SES) are increasingly recognized as foundational to students' overall development and success in school settings. Social and emotional skills encompass a complex set of abilities that enable individuals to manage their emotions, build and maintain relationships, navigate social scenarios, and make responsible decisions (Denham et al., 2012). However, there is no consensus on the definition of these skills, as discussed later.

Considering their relevance, the rising rates of behavioral and emotional difficulties reported in national surveys by the Istituto Superiore di Sanità (ISS, 2023) and the Ministero della Salute (2022) in Italy underscore the urgency of early, school-based interventions. These challenges frequently co-occur with academic underachievement (INVALSI, 2025), creating a cycle that can hinder long-term educational and social outcomes. In addition, along with strong research evidence (Chernyshenko et al., 2018; Oberle et al., 2024; Villares et al., 2023), anyone familiar with school environments understands that mastering emotions, working well with peers, and managing challenges are just as vital to students' daily lives as academic skills. It's often said that SES are what make learning possible in the first place. As Immordino-Yang and Damasio (2007) compellingly noted, "*We feel, therefore we learn,*" highlighting the deep connection between emotion and cognition. Without emotional safety, self-regulation, and a sense of connection, students may struggle to engage with academic material fully. Therefore, SES should be viewed not as an optional extra but as a fundamental part of education.

As mentioned, these skills are crucial to the development of children and adolescents, with strong evidence linking them to positive outcomes across cognitive, behavioral, and emotional areas (Jones et al., 2015; Taylor et al., 2017). Importantly, SES provide immediate benefits, such as those mentioned above improved academic performance and classroom behavior and are also significant predictors of long-term well-being and success in adulthood (Chernyshenko et al., 2018; Guo et al.,

2023). Longitudinal research indicates that greater socio-emotional competence in childhood correlates with better mental health, higher educational achievement, more stable employment, and reduced criminal activity later in life (Moffitt et al., 2011; Jones et al., 2015). For instance, data from the OECD (2021b) and Eurostat (2023) reveal that adults who scored higher in emotional regulation, cooperation, and prosocial behaviors during adolescence report greater life satisfaction, increased civic engagement, and better employment prospects across Europe. According to recent OECD findings (2023), individuals with stronger social-emotional skills during adolescence also experience higher life satisfaction, better mental health, and improved job opportunities as adults.

Yet, there is still considerable confusion around what exactly counts as social and emotional skills; terms like *soft skills*, *life skills*, *non-cognitive skills*, and *character traits* are often used interchangeably, even when they refer to different constructs. This has created what researchers call a “jingle-jangle” problem: using other names for the same thing or applying the exact name to various things. This lack of clarity makes it hard to compare studies or to design coherent interventions. To bring some order to this complexity, one of the most widely accepted and school-relevant frameworks is the five-domain model by the Collaborative for Academic, Social, and Emotional Learning (CASEL, 2012). Initially created for school-based intervention research, it has become popular in developmental psychology and educational science due to its clear structure and empirical support (Oberle et al., 2016; Zins et al., 2004). This framework divides SES into five interconnected areas: *self-awareness* (identifying one’s emotions, thoughts, and values), *self-management* (controlling emotions and behaviors to achieve goals), *social awareness* (empathizing with others and understanding different viewpoints), *relationship skills* (effective communication, cooperation, and conflict resolution), and *responsible decision-making* (making ethical and constructive choices). Another widely adopted model, such as the “Big Five Model” proposed by the OECD (2018), considers temperament and personality traits as the foundational basis for the development of social and emotional skills. While this trait-based approach offers valuable insights, especially for long-term prediction and individual profiling, this dissertation focused instead on more malleable and context-

sensitive factors, given its specific reference to the school environment. In educational settings, where daily interactions and structured interventions can significantly shape behavior, a biopsychosocial perspective was deemed more appropriate for informing preventive and scalable strategies.

Another reason to choose the five-domain model by CASEL (2020) is that a growing body of psychometric and cross-cultural research supports the validity of its structure. For instance, Davidson et al. (2018) validated a popular self-report tool (WCSD-SECA), which is aligned with the CASEL framework, revealing clear factor structures corresponding to the five core competencies. Additional research has supported the model's internal consistency and cross-age reliability across various educational environments (Weissberg, 2019; Yang et al., 2018). Developmentally, the model also aligns well with observed socio-emotional growth patterns. Skills such as self-awareness and emotion recognition emerge earlier in childhood, while others, including conflict resolution and ethical reasoning, develop more gradually throughout adolescence (Denham et al., 2012; McKown, 2017). Thus, this will be the next paragraph topic that will address the development of SES. In this dissertation, the term '*development*' is not used in its traditional, maturational sense—referring to the natural unfolding of socio-emotional skills at specific ages—but rather to indicate a process of growth and promotion, intentionally supported by environmental inputs. Specifically, it refers to how schools, through deliberate pedagogical actions and structured practices, can foster and scaffold the acquisition of social and emotional skills over time.

1.2 The Development of SES

Anyone who has watched children grow — whether as a parent, teacher, or in daily life — knows how quickly their emotional world changes during school years. It's common to see children respond differently to similar situations over time, as they experiment with various strategies while gradually learning to understand themselves and others. Indeed, the development of socio-emotional competencies is strongly dependent on the environment. As will be discussed, this dissertation

highlights that social and emotional skills emerge from the dynamic interplay between biology and environment (Sameroff, 2010; Bronfenbrenner, 1979). According to Sameroff's transactional model, children's outcomes stem from ongoing, reciprocal interactions between personal characteristics and contextual factors, rather than solely innate qualities or environmental conditions (Sameroff, 2010).

Neuroscientific developmental models enable us to understand the significant role of the environment and the impact of sensitive time windows on SES development. A key first element is that neuroscientific models highlight that brain development is not uniform but hierarchical: subcortical structures, such as the amygdala, mature early and guide early emotional learning, while prefrontal areas (such as the prefrontal cortex, PFC), responsible for cognitive control, develop more slowly over time (Casey et al., 2008; Tottenham, 2015). In early childhood, the amygdala plays a crucial role in processing emotionally salient stimuli, helping the child learn what is safe and what is not, even before they can consciously regulate those emotions (Tottenham, 2017). Studies have found that amygdala activation was almost excessive until pre-adolescence, showing that it was activated in response to any stimulus (Gee et al., 2013). Indeed, the amygdala appears to be a 'tutor' that establishes initial emotional salience maps which will later scaffold more complex regulatory strategies (Tottenham, 2017).

Observations have shown that the time window for amygdala activation is extensive, lasting until approximately age 9 (Casey et al., 2019). Although this wide window was initially seen as 'negative' or 'slow', studies have shown that it is a necessary time for the development of emotional and regulatory skills. It is precisely at this window that the adult, the caregiver, can act as a scaffold for the neural system (Gee & Cohodes, 2021). For example, some studies have even found that there are parent-dependent sensitive periods during which children rely on their caregiver's presence to calm down; in their absence, they are unable to deactivate their activation response (Hostinar et al., 2015; Moriceau & Sullivan, 2006). This is linked to the counterintuitive relationship between early childhood adversities and stress and the development of SES. In other words, while common sense has often held that those who experience early childhood adversities do not develop SES and therefore

have a deficit, research has shown that, on the contrary, it is precisely this continuous exposure to amygdala activation and the absence of a caregiver who acts as scaffolding that forces them to develop self-regulation skills. This does not mean, of course, that adaptive responses are created: it is precisely the environment that can make the difference in this regard.

As children progress into preadolescence, there is typically a shift in functional patterns: amygdala reactivity tends to decrease, while PFC engagement increases, allowing for more flexible and reflective emotion regulation (Silvers et al., 2017; Crone & Dahl, 2012). Indeed, during preadolescence, the emerging ability to decouple from caregivers and rely more on self-guided regulation mirrors the maturation of cortical-subcortical connectivity, including a shift toward more inhibitory prefrontal–amygdala coupling (Silvers et al., 2017; Gee et al., 2013). Still, this shift does not represent a simple takeover by cortical systems; rather, it reflects how the quality of earlier emotional experiences has contributed to the development of functional pathways that support mature regulatory strategies. Once again, the amygdala acts as a tutor for emotional experiences. Still, at this stage of development, it works in synergy with the PFC, allowing emotional responses to be self-regulated (Tottenham, 2015, 2017). The more advanced and trained the connection between the two is, the greater the self-regulatory skills will be. It is clear that, at this point, early experiences themselves map the stimuli to which the amygdala reacts. For this reason, early experiences in interaction with the environment and with the caregiver play a central role before the PFC becomes predominant. Calkins and colleagues (Calkins et al., 2004; Perry et al., 2016) argue that emotional regulation is not only a neurobiological capacity but also a learned skill, developed through consistent and attuned interactions with caregivers, peers, and later, teachers. Throughout childhood, repeated social experiences — including cooperative play, adult modeling, and emotional feedback — help consolidate the skills required for social and emotional competencies. It is increasingly acknowledged that brain-based and relational factors are not separable but mutually constitutive: social interactions actively shape neural circuitry, while neurobiological maturation determines the capacity to benefit from these interactions (Panksepp & Biven, 2012; Perry et al., 2016).

Given the extended developmental window of affective plasticity, emotionally secure and socially responsive classroom environments represent a key site of intervention to promote socio-emotional competence, particularly for children lacking consistent relational scaffolding at home (Bierman et al., 2010; Immordino-Yang & Damasio, 2007). Early experiences with caregivers, teachers, and peers in emotionally supportive and structured settings have a considerable influence on SES development (Denham et al., 2012; Sameroff, 2010). Since children and adolescents spend much of their formative years at school, the school environment becomes vital for fostering and improving SES. It provides a practical setting where students can practice, refine, and internalize socio-emotional skills through meaningful social interactions in a safe, supportive environment guided by teachers (Jennings & Greenberg, 2009; Jones et al., 2015; Oberle et al., 2016). Schools also serve as significant preventive spaces, not only helping to reinforce existing skills but also helping students who may be lagging in socio-emotional development. Additionally, school-based observations are crucial for the early identification of students who may benefit from targeted, specialized interventions to support their emotional and relational well-being (Domitrovich et al., 2017; Cefai et al., 2018). Thus, the following paragraph will focus on how to foster SES in the school context.

1.3 SES at School

As said, the OECD (2023) highlights the importance of integrating socio-emotional learning into curricula, teacher training, and school climate programs, emphasizing that schools are among the most effective and scalable environments for developing these essential life skills. Although there is strong empirical evidence supporting the importance of SES in formal education, such practice remains limited. One of the primary barriers is that many teachers receive little to no training in how to teach SES (Weissberg, 2019) explicitly. As a result, they may not feel responsible for students'

socio-emotional development or may assume these skills will emerge naturally through social interactions (Schonert-Reichl, 2017; Oberle et al., 2016).

Indeed, SES can be both taught and learned, much like other aspects of schooling. However, teachers often do not prioritize it, expecting children and young people to develop skills like self-regulation, prosocial behavior, and empathy naturally. The latest results on SES and teachability in schools demonstrate, in various ways and on different levels, that teaching SES in schools is effective (Steponavičius et al., 2023). In Italy and other European countries, however, national policies on social and emotional learning are often lacking or only partially developed, resulting in inconsistent implementation at the school or classroom level (Cefai et al., 2018). As a result, SES instruction often relies on individual teachers' initiative, who may lack adequate training, time, or institutional support to use evidence-based methods. Structural challenges, such as strict curricula, pressure for academic achievement, and inadequate teacher preparation, further hinder the integration of SEL frameworks into daily school life (Weissberg, 2019).

Research consistently indicates that the most effective ways to promote social and emotional skills are those based on proven frameworks and executed with high fidelity, especially when integrated into daily classroom activities (Durlak et al., 2011; OECD, 2015). Instead of existing as separate programs, recent research indicates that incorporating SES instruction into core academic subjects enhances both acceptance and long-term sustainability, while reducing content overlap and improving implementation outcomes (Steponavičius et al., 2023). This integrated approach supports broader educational goals, allowing teachers to develop socio-emotional skills without significantly reducing instructional time. Additionally, new technologies such as digital platforms, virtual agents, and biofeedback devices are increasingly being used to enhance SES growth in schools (Slovák & Fitzpatrick, 2015). As discussed further in this dissertation, these innovations present promising opportunities to supplement traditional teaching methods and enable more personalized, scalable interventions.

A final note, though not directly related to this thesis's main topic, concerns the numerous opportunities teachers have to improve SES without targeted interventions. These include small actions that foster a favorable classroom climate, such as gaining a deeper understanding of students, establishing clear routines, validating students' emotions, and encouraging cooperative activities. Additionally, incidental learning moments, such as arguments, misunderstandings, or minor conflicts, can be transformed into meaningful learning experiences if approached in the right way. However, this kind of incidental work is only truly effective when teachers have previously engaged in more structured approaches to SES development and have internalized key strategies for scaffolding students' social and emotional growth.

Considering the developmental importance of SES, especially for early prevention and support, it's crucial to identify and track these skills using methods that are age-appropriate and relevant to the context. The following section discusses the conceptual and methodological issues in measuring SES among school-aged children.

1.4 Measurement of Social and Emotional Skills in School-Age

Given the importance of SES and the vital developmental period of schooling, understanding how to develop and support these skills requires knowing how to measure them. However, a clearer picture of how these competencies develop and how to best assist them largely depends on their definitions and measurement methods. While there is general agreement on their developmental importance, researchers still encounter significant challenges in reliably capturing SES, especially in school-aged children. These difficulties arise from variability in how SES is conceptualized, the need to consider age-related variations, and practical limitations within school environments. This section examines the current state of SES assessment in children, focusing on the tools employed, debates about their validity, and the broader implications for educational research.

1.4.1 Conceptual and Structural Challenges

A significant challenge in SES research is the lack of a universally accepted taxonomy and definitions. Although frameworks like CASEL (2020) offer a clear and empirically supported five-domain structure, different studies use widely varying definitions of SES (Domitrovich et al., 2017). Some research focuses on narrow constructs such as emotional regulation or empathy, while others use broader terms like emotional intelligence or life skills. This variation hampers comparability and consistency in research outcomes (Humphrey et al., 2011). Additionally, significant concept overlap among domains often raises questions about their discriminant validity, since many skills are interconnected and develop simultaneously (Denham et al., 2012). For instance, self-awareness and self-management are closely related and tend to build together, making it hard to distinguish whether they are separate abilities or parts of a broader regulatory system (Denham et al., 2012).

In addition to definitional inconsistencies, developmental variability poses a significant challenge for dependable measurement. Children's ability to understand and report their emotional and social experiences varies significantly with age, requiring tools that are both psychometrically reliable and developmentally suitable (Humphrey et al., 2011; McKown, 2017). For example, young children may struggle to engage with abstract response formats or introspective self-assessments, which can compromise the validity and reliability of self-report measures (Denham, 2015; Raver, 2002).

Finally, assessing SES within the school environment is complicated by the very nature of the setting. Often, measurements are taken by outsiders such as researchers or psychologists, which introduces a new variable that can influence outcomes. For instance, if a child is aware that a psychologist is conducting a SES intervention, they may respond differently, such as feeling they can calm down when agitated, to demonstrate their competence. Furthermore, the applicability of these findings is limited because they typically pertain to specific school hours, interventions, or teachers, reducing their relevance and use outside the context of the SES project.

1.4.2 Methods of Assessment: Strengths and Limitations

In practice, SES are assessed through various methodologies, each with different advantages and limitations. The field is primarily divided into four main categories (refer to Table 1 for an overview): self-report measures, teacher reports, behavioral observations, and performance-based or physiological assessments.

- Self-report measures are among the most used tools, especially in large-scale school research. Examples like the WCSD Social and Emotional Competency Assessment (WCSD-SECA; Davidson et al., 2018) align with the five CASEL domains and demonstrate strong psychometric properties in school-aged groups. These tools are relatively simple to administer and can reflect subjective perceptions; however, they are also susceptible to social desirability bias, comprehension issues, and limited self-awareness, particularly in younger children (Crowder et al., 2019).
- Teachers offer valuable external observations of children's behavior in natural settings. Teachers can provide valuable insights into how students manage their emotions, interact with their peers, and cope with stress in the classroom. However, these reports can be influenced by the observer's expectations, relationships, and interpretations of the situation, which may lead to biases or differences between raters (Humphrey et al., 2011). Additionally, teachers might focus more on observable classroom behavior than on internal emotional states or subtle relational cues. Lastly, rating each student is time-consuming and requires considerable effort.
- Behavioral observations, whether structured (such as cooperative tasks or emotion recognition games) or naturalistic (like peer interactions during free play), provide ecologically valid and dynamic insights into children's abilities. Although regarded as a gold standard in developmental research, these methods are time-consuming, need trained observers, and encounter difficulties in standardization across different settings and raters (Denham, 2015; Humphrey et al., 2011).

- Performance-based tasks and physiological measures are increasingly studied within SES research. These involve assessments of executive functioning, affect recognition, or physiological regulation, such as heart rate variability. Although these methods offer objective data and reduce the biases of typical subjective reports, they can be resource-intensive, require specialized technical skills, lack generalizability of the skill, and still raise questions regarding their validity in representing SES constructs (McKown, 2017).

This dissertation does not aim to provide an exhaustive review of all available assessment methods for SES. Instead, the goal is to acknowledge the variety of existing tools and emphasize that the specific aims, contexts, and populations of each study should drive their use. What emerges clearly, however, is that no single method is sufficient on its own: a multi-method approach — combining subjective reports, external observations, behavioral tasks, and physiological indicators — offers the most comprehensive and accurate perspective on the development of social and emotional skills in school settings.

Table 1 – Synthesis of SES Methods of Assessment

<i>Method</i>	<i>Strengths</i>	<i>Limitations</i>	<i>Use in Thesis</i>
<i>Self-Report</i>	Efficient, low-cost, captures internal states, validated instruments available	Social desirability bias, language demands, limited introspective ability in young children	Used across multiple studies with age-appropriate adaptations
<i>Teacher Reports</i>	Contextual insights from observers, especially useful with younger children	Observer bias, context-dependent, may not reflect internal emotional states	No

<i>Behavioral Observations</i>	High ecological validity, real-time assessment of behavior in natural or structured settings	Time-intensive, needs trained coders, standardization and interpretation challenges	Used in structured tasks (e.g., cooperative game protocols)
<i>Performance-Based Tasks</i>	Objective assessment, often computer-based, less prone to social desirability	Limited availability of tasks, developmental validity concerns, interpretation challenges	No
<i>Physiological Measures</i>	Biologically grounded, provides insight into self-regulation (e.g., CVT)	Technically demanding, expensive, interpretation of physiological proxies debated	Integrated in CVT-based study as a marker of emotional regulation capacity

1.4.3 Multi-method Approaches and the Push for Ecological Validity

To overcome the limitations of any single method, researchers increasingly recommend using multiple assessment approaches and informants (Domitrovich et al., 2017; Guo et al., 2023). Combining self-reports, teacher ratings, physiological measurements, and observed behaviors provides a more comprehensive and detailed understanding of a child’s social and emotional development.

Although multi-method approaches offer benefits, they also present challenges. Different tools that evaluate similar SES areas vary greatly in content, format, and scoring, which complicates their integration and interpretation (McKown, 2017). Additionally, the absence of standardized definitions and cross-age validation remains a problem, limiting the ability to compare results and apply findings broadly (Humphrey et al., 2011).

Finally, measuring SES in real-world school settings faces practical challenges. Teachers often lack training in socio-emotional assessment, which can lead to reliance on external professionals who may – surprisingly – compromise reliability. External researchers, indeed, can become a disruptive factor as they influence the social desirability bias of children, who want to prove that they can do what is asked of them. Time constraints mean data collection competes with academic priorities (Collie et al., 2015). In many countries, including Italy, identifying and supporting SES remains largely informal, with few standardized protocols or collaborations between researchers and teachers. A 2018 EU report highlighted that, in several European education systems, SES development depends heavily on individual teachers' initiatives rather than institutional frameworks (Cefai et al., 2018). This lack of structural support decreases assessment consistency and risks worsening inequalities across classrooms and regions.

These difficulties in defining and measuring SES underscore the need for a comprehensive framework that captures its complex and multifaceted nature. The following chapter presents a biopsychosocial approach, highlighting how biological, psychological, and contextual factors interact to influence the development of SES in childhood and adolescence.

Chapter 2 | A Bio-Psycho-Social Approach for SES Development

2.1 Bio-psycho-social Approach to the Study of Social and Emotional Skills in Schools

Children are not inherently born with better or worse self-regulation, emotional expression, or prosocial skills. These are skills children can learn, and as educators, we can teach them. This understanding aligns with the bio-psycho-social framework (Bronfenbrenner, 1979) regarding SES development. Bronfenbrenner's model (1979) provides an excellent snapshot of the complexity and interrelatedness of the various systems (macro, meso, micro) that interact at multiple levels to influence developmental growth and, therefore, SES as well. This dissertation will focus primarily on certain proxemic factors, both environmental and personal, inherent to the school context. Indeed, as mentioned above, the development of SES during childhood and early adolescence is a result of ongoing interactions between individual traits and environmental factors that occur as children grow and learn. Consistent with transactional-developmental theories (Sameroff, 2010), this thesis employs a systemic approach, viewing SES as a set of dynamic competencies that develop through reciprocal exchanges between the child and their environment. Specifically, this thesis's conceptual model centers on two main, separate but interconnected domains (as will be discussed in Chapter 4): a biological and an environmental one. Biology and environment interact, defining the development of the phenotype, which includes students' SES.

At a biological level, we assessed children's Cardiac Vagal Tone (CVT), a psychophysiological marker of their self-regulation ability.

While at an environmental level, we analyzed classroom climate, which includes:

- Students' perception of classroom climate reflects their subjective evaluation of the social and emotional environment of their classroom experience.
- Teachers' well-being is a variable that directly influences students' development of SES according to the Prosocial Classroom Model (Jennings & Greenberg, 2009).

- Instructional practices, such as structured cooperative learning, naturally promote SES in a real, safe, and dynamic context. In this thesis, CL was tested as a (tech-supported) preventive intervention to enhance SES in primary and middle schools.

The following paragraphs will specifically analyze the biological and environmental factors that influence the development of SES at school.

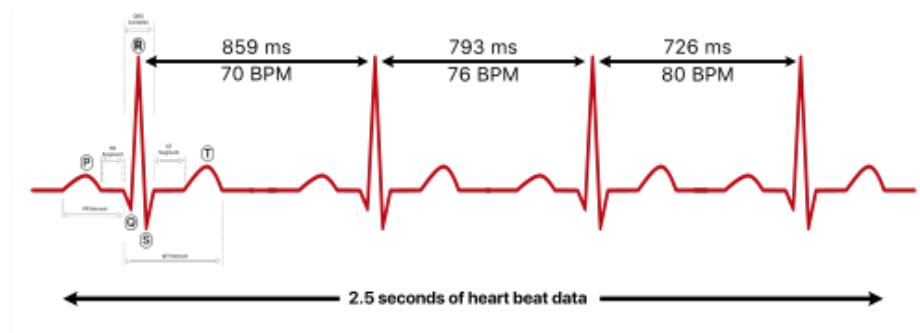
2.2 Biological Characteristic

Within a biopsychosocial perspective, biological factors undoubtedly play a significant role in the development of social and emotional skills. Yet, as previously discussed, it is through ongoing interactions with the environment that these biological predispositions are shaped and expressed. Among the most studied and increasingly recognized physiological markers in relation to SES is Cardiac Vagal Tone, which will be the focus of the following paragraphs.

2.2.1 Cardiac Vagal Tone

Cardiac vagal tone, indicating parasympathetic control of heart rate, is a well-established biomarker for emotional and behavioral self-regulation (Beauchaine & Bell, 2020; Calkins & Keane, 2004; Porges, 2007). It is considered a relatively stable individual trait, reflecting the ability to respond adaptively to internal and external environmental demands. Physiologically, CVT reflects the dynamic balance between the sympathetic and parasympathetic branches of the autonomic nervous system. While the sympathetic system mobilizes the body for action in response to perceived challenges (“fight or flight”), the parasympathetic system — primarily mediated by the vagus nerve — facilitates calming and restorative processes (“rest and digest”) (Porges, 2007; Siegel, 1999; Thayer & Lane, 2000). This balance is observed through fluctuations in heart rate, remarkably, the variability in the time intervals between successive heartbeats (interbeat intervals; see Figure 1 for a more precise representation), which will also be discussed in the following studies.

Figure 1 – Time Intervals Between Successive Heartbeats



High-frequency heart rate variability (HF-HRV) is the most used non-invasive index of cardiac vagal tone, capturing parasympathetic modulation of heart rate (Berntson et al., 1997; Laborde et al., 2018). In individuals with higher CVT, the parasympathetic system exerts stronger inhibitory control over cardiac activity at rest but also allows for flexible withdrawal during moments of arousal or task engagement. This physiological flexibility is thought to underlie effective emotion regulation, attentional control, and readiness for social interaction, all of which are core components of socio-emotional competence (Beauchaine, 2015; Porges, 2007; Thayer & Lane, 2009).

Theoretical frameworks, such as the Polyvagal Theory (Porges, 2007) and the Neurovisceral Integration Model (Thayer & Lane, 2009), interpret vagal regulation as a physiological basis for adaptive interaction, self-regulation, and social functioning. These models illustrate how vagal tone promotes a calm, attentive state that fosters prosocial behavior and readiness to learn. It is precisely those models that, as mentioned in Chapter 1, have identified how vagal heart tone plays a key role in the relationship between the amygdala and the PFC (Thayer & Lane, 2009). Indeed, having good self-regulation skills enables you to effectively manage your emotional response when faced with internal or external stimuli, allowing you to function correctly. In Siegel's Window of Tolerance (Siegel, 1999) view, knowing how to self-regulate enables you to be in the “green zone”, that zone where there is a good balance between the sympathetic and parasympathetic systems. The more you can flexibly return to the tolerance zone, the more you are a good regulator and, therefore, have a good CVT, which is the perfect level of activation required for good functioning. When children stay within this window, they are more able to engage with peers, manage frustration, and benefit from

classroom activities. In contrast, diminished vagal regulation can narrow this window, making emotional dysregulation or withdrawal more likely when facing environmental challenges (Porges, 2007).

Empirical studies confirm these views, indicating that children with greater vagal flexibility tend to exhibit lower emotional reactivity, increased prosocial behavior, and better interpersonal adjustment (Beauchaine & Bell, 2020; Gentzler et al., 2013). In educational settings, CVT has been examined as a predictor of behavioral adjustment and classroom engagement; however, its direct effect on SES is still being researched. That said, this thesis considers CVT as a biologically rooted trait that influences children's socio-emotional development through interactions with social and educational environments.

2.3 Environmental Characteristics

As stated in Chapter 1, the development of SES heavily depends on environmental factors. Through interacting with their environment, children learn to identify threatening stimuli and strengthen the connection between the amygdala and PFC, which helps in self-regulation in response to environmental cues. In the first years of life, infants rely almost exclusively on their primary caregiver, often supported by extended family members, for both physiological and emotional regulation (Calkins & Keane, 2004). These early caregiving relationships provide a secure base from which the child begins to engage in foundational social interactions, laying the groundwork for subsequent socio-emotional competencies (Calkins & Keane, 2004). As children transition into early educational settings, the developmental ecology expands beyond the immediate family context. School becomes the predominant environment in which children spend their time, exposing them to novel social dynamics and a broader array of interpersonal expectations. Within this setting, interactions with teachers and peers function not only as sources of socio-emotional modeling but also as opportunities for scaffolding and practicing increasingly complex emotion regulation and social skills (Denham et al., 2007). Consequently, the quality of the classroom's socio-emotional

climate constitutes a critical environmental determinant of children's socio-emotional trajectories, shaping their capacity to navigate relationships, manage affective states, and adapt successfully to social challenges (Wang et al., 2019). Toward the end of elementary school and the beginning of secondary school, socio-emotional interactions within school and classroom environments become increasingly significant (Jones et al., 2015). This developmental phase coincides with a sensitive period during which environmental influences have a profound impact on brain architecture and social functioning. As Casey and colleagues (2025) emphasize, adolescence is marked by heightened neural plasticity, particularly in circuits underlying social motivation, emotional reactivity, and goal-directed learning. During this time, children transition from reliance on caregivers to navigating more complex peer dynamics and forming social bonds outside the family. The classroom thus represents not only an academic setting but also a primary socio-emotional arena where interactions with teachers and peers can either scaffold adaptive emotion regulation and social skills or exacerbate vulnerabilities (Hamre & Pianta, 2006).

Notably, while entering early adolescence and even before, in late childhood, the brain shows amplified sensitivity to social cues and rewards, with subcortical systems (e.g., ventral striatum and amygdala) responding strongly to peer presence and emotionally charged contexts, while prefrontal regulatory regions are still maturing (Casey et al., 2025). This neurodevelopmental imbalance renders these age students particularly attuned to classroom climates (Hamre & Pianta, 2006). Indeed, supportive, safe environments can foster positive identity development, cooperation, and prosocial behaviors, whereas harmful, threatening, or socially exclusionary climates may increase risk-taking, emotional dysregulation, or social withdrawal. In this sense, the classroom becomes a potent driver of socio-emotional trajectories, shaping not only immediate behavior but also long-term patterns of social cognition and self-concept as students' progress toward adulthood.

Yet, the classroom is a living organism and as such it is composed of many systems interacting with each other over time. To understand how this environment interacts with the child's

characteristics to shape the development of SES, we need to define the classroom climate and address the different systems that comprise it.

2.3.1 Classroom Climate

Much like a sports team that struggles to cooperate won't play well, won't grow, and certainly won't win, a classroom where the social atmosphere is tense or unbalanced quickly becomes a place where learning and well-being are compromised (Wang et al., 2020). A class is, after all, a group of individuals who spend hours together every day, and this shared environment can either feel like a stuffy, overheated room with no open windows or like a vast green park where a gentle breeze makes it easy to breathe, move, and grow. Classroom climate is a fragile and often underestimated balance, yet students perceive it acutely. While research has firmly established classroom climate as a strong predictor of academic and social-emotional outcomes, it remains a rarely prioritized focus in school practice. Before delivering any instructional content, teachers must first ask themselves: What kind of social and emotional space am I creating for my students?

Rather than being a static feature, classroom climate is now seen as a dynamic, multidimensional construct shaped by daily interactions between teachers and students (Hamre & Pianta, 2006; Wang et al., 2020). According to Wang et al. (2020), classroom climate comprises three interconnected domains: *instructional support*, *socioemotional support*, and *classroom organization and management*. These dimensions reflect both pedagogical effectiveness and the emotional and behavioral atmosphere of the classroom, which together create the developmental scaffolding necessary for students' social and emotional growth.

Instructional support refers to teaching practices that foster students' cognitive engagement and metacognitive awareness, including the provision of meaningful feedback, the encouragement of reflection, and the promotion of autonomy (Wang et al., 2020).

Socioemotional support encompasses the emotional quality of teacher-student and peer relationships, emphasizing warmth, responsiveness, and respect. A classroom environment where students feel emotionally safe and valued promotes secure attachment representations and supports the development of SES (Jennings & Greenberg, 2009; Pianta & Hamre, 2009; Wang et al., 2020).

Classroom organization and management pertain to teachers' ability to structure the environment through clear expectations, consistent routines, and effective behavioral regulation. Well-managed classrooms reduce stress and unpredictability, facilitating a sense of security (Porges, 2007) that is essential for learning and social engagement (Wang et al., 2020).

Building on Wang et al.'s (2020) multidimensional conceptualization of classroom climate as a constellation of interpersonal, instructional, and organizational processes shaping students' experiences, the present model identifies four interrelated domains that collectively influence the development of socio-emotional skills. First, students' perceptions of classroom climate constitute a central indicator of its quality, reflecting their subjective appraisal of the classroom as emotionally safe, socially supportive, and academically meaningful. Prior research shows that these perceptions often predict socio-emotional adjustment more robustly than objective classroom features (Oberle et al., 2014), highlighting the importance of students' lived experience in understanding developmental outcomes.

These perceptions, in turn, are strongly shaped by teacher-related factors. One of the most relevant is teachers' well-being, which encompasses emotional exhaustion, occupational stress, and overall job satisfaction, and emerges as a foundational condition for cultivating a favorable classroom environment. According to the Prosocial Classroom Model (Jennings & Greenberg, 2009), indeed, emotionally healthy teachers are better equipped to provide nurturing, responsive, and well-regulated learning environments that support the development of SES.

Finally, instructional practices serve as a key mechanism through which the preceding dimensions are translated into students' daily experiences. Structured cooperative learning, for example, creates real-life, task-oriented opportunities for students to practice emotional regulation, communication,

and perspective-taking, all of which are scaffolded by teacher support and peer interaction (Roseth et al., 2008; Van Ryzin & Roseth, 2019a). Importantly, these practices do not operate in isolation: they are facilitated by teachers' well-being and confidence in teaching socio-emotional content, which together shape the overall classroom atmosphere and, consequently, students' perceptions of it. Thus, classroom climate is best understood as a dynamic, multi-layered construct in which student experiences, teacher characteristics, and instructional approaches are interwoven, jointly shaping the social-emotional learning environment.

2.3.2 Perception of Classroom Climate

From a student's perspective, classroom climate is not a fixed structure, but a lived experience composed of multiple interacting cues: the quality of relationships with teachers and peers (e.g., bullying episodes), the perceived fairness (e.g., evaluation rules) and clarity of rules, the consistency of expectations, and the overall emotional tone of the learning environment. This subjective lens is deeply personal. It is shaped not only by what happens in the present but also by each student's prior experiences, including how safe or threatened they have felt in relationships with adults, and how peers have treated them. Especially during adolescence, when peer influence becomes stronger (Giletta et al., 2021), perceptions of inclusion, belonging, or exclusion can significantly influence how students engage with the social and emotional aspects of classroom life. In this light, what a student *perceives* matters as much as — if not more than — what objectively occurs.

When faced with internal or external stimuli, the individual self-regulates their response, not only through their self-regulation competence (indexed as mentioned above by the CVT), but also in how they perceive the stimuli they encounter. This perception acts as a lens through which students interpret their social experiences, shaping their motivation to participate, express emotions, and build relationships. While structural characteristics of classrooms — such as teacher–student ratios or instructional formats — are frequently used as general indicators of educational quality, research suggests that students' perceptions of classroom climate serve as stronger predictors of their

emotional and behavioral adjustment. For instance, Way et al. (2007) found that deviations in early adolescents perceived classroom climate over time were significantly associated with trajectories of psychological well-being and behavioral adjustment, regardless of objective classroom features, underscoring the importance of subjective perception. Perceived emotional safety, which refers to students' sense of being safe, supported, and free from emotional threat in the classroom, has been consistently associated with fewer internalizing symptoms and greater cooperative engagement (Way et al., 2007; Wang et al., 2020). Thus, this dissertation examines whether students' subjective perceptions of the classroom environment, particularly their relationships with teachers and peers, influence the development of SES.

2.3.3 Teachers

As discussed earlier, teachers are key figures within this setting, functioning not only as educators but also as emotional and relational agents. Their personal well-being and confidence in their teaching abilities significantly influence how they manage classrooms, cultivate peer relationships, and address students' emotional needs. The following paragraph will explore two main environmental factors affecting SES: teacher well-being and their perception of effectiveness in teaching the same skills.

The Prosocial Classroom Model (Jennings & Greenberg, 2009) suggests that teachers with high emotional well-being are better equipped to create classroom environments that are safe, structured, and supportive. As illustrated in Figure 2 (Jennings & Greenberg, 2009), teachers' social-emotional competence and well-being have a direct impact on students' social, emotional, and academic outcomes. Through their influence on teacher–student relationships, classroom management, and the overall classroom climate, teachers' emotional health becomes a (first) central driver of positive developmental trajectories.

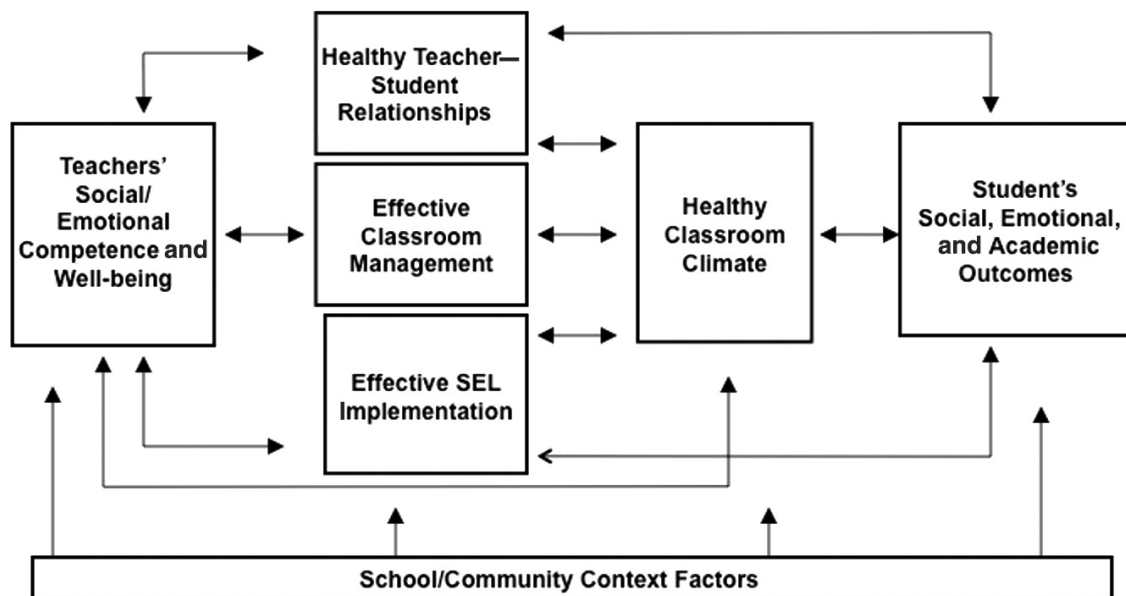


Figure 2 - The Prosocial Classroom Model (Jennings & Greenberg, 2009)

Indeed, when teachers feel emotionally healthy, they tend to model good emotional regulation, interact positively with students, and employ relational teaching methods, such as cooperative learning. Conversely, teachers experiencing emotional exhaustion or psychological distress may struggle to maintain a favorable climate, respond sensitively to students' emotions, or manage group dynamics effectively (Oberle et al., 2016). Indeed, stress and burnout can impair teachers' emotional availability and classroom management, thus diminishing opportunities for students to participate in interactions that foster SES growth.

While this dissertation does not contain direct data connecting teacher well-being with student SES outcomes, one of the included studies (Zagni et al., 2025) investigated Italian teachers perceived stress and emotional exhaustion. The Italian context lacked sufficient data, which could serve as a starting point for further research into classroom climate, safety, and SES development. Although we cannot establish causality, it can be hypothesized that stress may hinder teachers' ability to develop and maintain supportive emotional environments, which are crucial for promoting SES in students.

Taken together, these elements that shape the classroom climate play a fundamental role in the development of SES at school. The next chapter will present the Cooperative Learning teaching methodology as a possible preventive intervention, also shaping the classroom climate to support the development of SES.

Chapter 3 | Cooperative Learning to Boost SES

3.1 Cooperative Learning

As described in the model by Wang et al. (2020), the way in which teachers organize classroom practices is one of the three key factors that shape the classroom climate, which is fundamental for the development of SES.

Within this domain, CL stands out as one of the most structured and empirically supported methods for fostering SES in schools. This pedagogical approach is designed around intentional peer cooperation and interdependence. Multiple systematic reviews and meta-analyses, based on Social Interdependence Theory (Johnson & Johnson, 2009), have consistently shown that cooperative learning improves academic performance, interpersonal relationships, and social-emotional growth (Roseth et al., 2008; Van Ryzin & Roseth, 2019b; Järvelä et al., 2023). In addition, it provides a meaningful and authentic context where students can practice, refine, and internalize SES through genuine interactions within a safe, emotionally nurturing environment, supported by teacher guidance and classroom norms (Järvelä et al., 2023; Van Ryzin & Roseth, 2019; Zagni et al., 2025).

3.1.1 A Definition of CL

Teachers often refer to “group work” as CL. For this reason, they complain about the ineffectiveness of the methodology because they expect that putting students in groups is equivalent to CL. CL, however, is not about doing an activity in a group that you could have easily done alone. Instead, CL is a precise methodology based on four (or five, in some more orthodox strands of the literature that include *Promotive Interaction*) theoretical principles related to Social Interdependence Theory (Johnson & Johnson, 2009).

Cooperative learning involves teaching methods that organize students into small, structured groups where success depends on cooperation and shared objectives (Johnson et al., 1994). Unlike simple group work, CL is characterized by intentional task design, mutual responsibility, and embedded opportunities for interpersonal engagement. Its foundational assumption is that learning is

not only a cognitive but also a social process: cooperation requires students to actively coordinate with others, manage conflicts, and negotiate shared meaning. As such, CL provides a unique classroom ecology in which socio-emotional skills can be both elicited and strengthened (Low & Van Ryzin, 2024; Zagni et al., 2025).

Cooperation itself can be described as a social interaction in which individuals coordinate actions and share responsibilities to achieve a common goal. It relies on mutual engagement, shared intentionality, and aligned purposes among participants (Warneken & Tomasello, 2009). Learning to cooperate requires the ability to inhibit the impulse to act alone and to synchronize one's actions with others (Zagni et al., 2024). This skill is supported by proactive cognitive control, a brain function located in the Prefrontal Cortex (PFC), which activates when a person feels safe, referred to as the Window of Tolerance (Siegel, 1999; Thayer & Lane, 2009). From a developmental perspective, cooperation involves individuals actively managing their behavior while also responding to others' actions and emotions in a shared task (Mastromatteo et al., 2024). As discussed, PFC develops and matures, particularly during pre-adolescence, making this age group a crucial sensitive window in relation to cooperative behaviors.

However, cooperatively structuring lessons is not an easy task for teachers. Empirical and theoretical frameworks highlight that four key principles are necessary for effective CL implementation (Johnson et al., 1994; Johnson & Johnson, 2009):

- *Positive Interdependence*: Each member's success is tied to the group's success. Students must rely on one another to reach the shared goal, fostering collaboration over competition.
- *Individual Accountability*: Each student is responsible for their own contribution. This discourages free-riding and encourages personal engagement and self-regulation.
- *Social Skills Development*: Interpersonal skills, such as turn-taking, empathy, negotiation, and feedback, are explicitly taught and practiced.
- *Group Processing*: groups reflect on their functioning, discussing what worked, what didn't, and how they can improve, thereby enhancing metacognitive awareness of social dynamics.

3.1.2 CL and SES Promotion

When all four principles are implemented consistently, CL becomes a powerful context for developing a wide range of socio-emotional skills in a real, scaffolded, and safe environment. Indeed, the structured nature of CL — built around mutual goals, shared accountability, and explicit social engagement — creates repeated and meaningful opportunities for students to practice perspective-taking, regulate emotions, engage in constructive dialogue, and resolve conflicts (Roseth et al., 2008; Van Ryzin & Roseth, 2019a). Specifically, *positive interdependence* ensures that students rely on one another to succeed, which enhances prosocial motivations and mutual support. *Individual accountability* fosters responsibility and self-regulation, as each member is expected to contribute meaningfully. Explicit *teaching of social skills* (e.g., active listening, perspective-taking, constructive feedback) promotes the interpersonal competencies necessary for effective collaborative work. Lastly, *group processing* — reflecting on how the group functioned — encourages metacognitive awareness of social behavior and supports adaptive group dynamics (Gillies, 2016; Zagni et al., 2025).

Empirical studies have provided robust support for these connections. A meta-analysis by Roseth et al. (2008) found that students engaged in cooperative learning reported higher peer acceptance, more prosocial behavior, and fewer conduct problems compared to peers in competitive or individualistic classrooms. Similarly, Van Ryzin and Roseth (2019b) showed that cooperative learning predicted longitudinal improvements in peer attachment, emotional support, and school engagement, particularly among middle school students. In experimental settings, Zagni et al. (2025) found that classrooms implementing structured CL sessions exhibited significant increases in emotional knowledge, social awareness, and relationship skills. Taken together, these findings highlight CL not only as a method for cognitive growth but as a developmental environment where SES are naturally activated, exercised, and internalized.

Yet, research consistently indicates that the success of cooperative learning relies on faithfully implementing its core principles. Research has shown that classrooms implementing all four

principles demonstrate significantly higher academic and socioemotional gains compared to those that apply only some or none of them (Johnson & Johnson, 2009; Roseth et al., 2008). Without careful structuring, group activities may devolve into social loafing, conflict, or exclusion, undermining the potential benefits.

However, applying these principles with fidelity is far from straightforward, especially in today's increasingly diverse and demanding classrooms. Anyone who has spent time in a real classroom knows how messy group work can be (Buchs et al., 2017). Even when the intention is to implement high-quality CL, the reality often falls short: some students dominate. In contrast, others disengage, tasks become fragmented, and teachers are left managing a flurry of interactions without the time or tools to monitor them meaningfully. Moreover, teachers often face structural constraints such as large class sizes, limited training in socio-emotional pedagogy, and time pressure from standardized curricula. As a result, even well-intentioned attempts at cooperative learning may fall short of their potential unless educators are supported by practical tools and training that help them structure, monitor, and sustain high-quality collaboration. This raises a pressing question: how can teachers realistically implement these demanding pedagogical principles in everyday classroom settings that are complex, fast-paced, and emotionally heterogeneous?

3.1.3 Tech-supported CL

Despite the well-documented benefits of CL when implemented with fidelity, the everyday complexity of classroom life makes it genuinely challenging to consistently uphold all four of its core principles. And here lies the paradox: we know what works, but we struggle to do it well — especially at scale, across diverse classrooms, with varied teacher experience and student needs.

This is where thoughtfully designed technology can make a difference, not as a gimmick or a substitute for teaching, but as a scaffold that supports the conditions for quality collaboration to take root and thrive. Emerging research has begun to explore how digital tools can help teachers

implement structured peer interactions with greater fidelity, particularly in maintaining role clarity, ensuring equitable participation, and facilitating reflective processing (Slovák & Fitzpatrick, 2015; Zagni et al., 2025). The PeerLearning.net software represents one of the first attempts to embed the four CL principles directly into the flow of classroom practice, not through abstract training sessions, but through concrete, in-the-moment guidance for both teachers and students.

3.1.4 PeerLearning.net Software

PeerLearning.net is a web-based platform explicitly designed to scaffold both teachers and students through structured, evidence-based CL activities¹. Developed in alignment with decades of research (Johnson & Johnson, 2009; Gillies, 2016; Van Ryzin & Roseth, 2019a, b), the platform operationalizes all the key principles of CL (more detailed descriptions are included in Chapters 6 and 7). Each lesson within PeerLearning.net is structured around one of four validated CL formats — group projects, group inquiry, peer tutoring, or jigsaw — each fostering task- or role-based interdependence. This design ensures that no student can complete the task alone, encouraging mutual reliance and collaboration. Individual accountability is maintained through clearly defined roles and task expectations, while social skills are explicitly introduced at the beginning of each module using embedded modeling and goal-setting activities. During the lesson, students are prompted to apply a targeted socio-emotional skill (e.g., turn-taking, help-seeking, conflict resolution), with the teacher reinforcing observed behaviors through a point-based group reward system grounded in Positive Behavioral Support (PBS) principles (Sugai & Horner, 2009).

The platform's group processing phase further enhances learning. At the end of each lesson, students engage in both collective and individual reflection on the quality of their collaboration and their socio-emotional performance. Teachers are guided through this process by the platform, which

¹ For more detailed information, lesson examples, and explanatory videos, please visit www.peerlearning.net.

reduces their cognitive load and supports the fidelity of implementation. It offers real-time prompts, automates group and role assignments, and supports the alignment between academic tasks and SEL goals. Empirical studies have demonstrated that this structured approach leads to measurable gains in both observable behaviors and self-reported SES growth, including improvements in emotional knowledge, social awareness, relationship skills (Zagni et al., 2025; Low & Van Ryzin, 2024), and teachers' stress and burnout (Anton & Van Ryzin, 2024).

Although multiple studies conducted in U.S. high schools have shown the effectiveness of PeerLearning.net in fostering prosocial behavior, peer relationships, and reducing aggressive conduct (Low & Van Ryzin, 2024; Zagni & Van Ryzin, 2025), no attempts have yet been made to implement or evaluate this tool in European school settings. Furthermore, there is currently a lack of available data on SEL interventions that combine cooperative learning and technology within a preventive, school-based framework. To begin addressing this gap, the present thesis includes two studies to assess whether PeerLearning.net could serve as a viable approach to support the development of SES (behavioral and self-reported) in primary and middle school Italian classrooms.

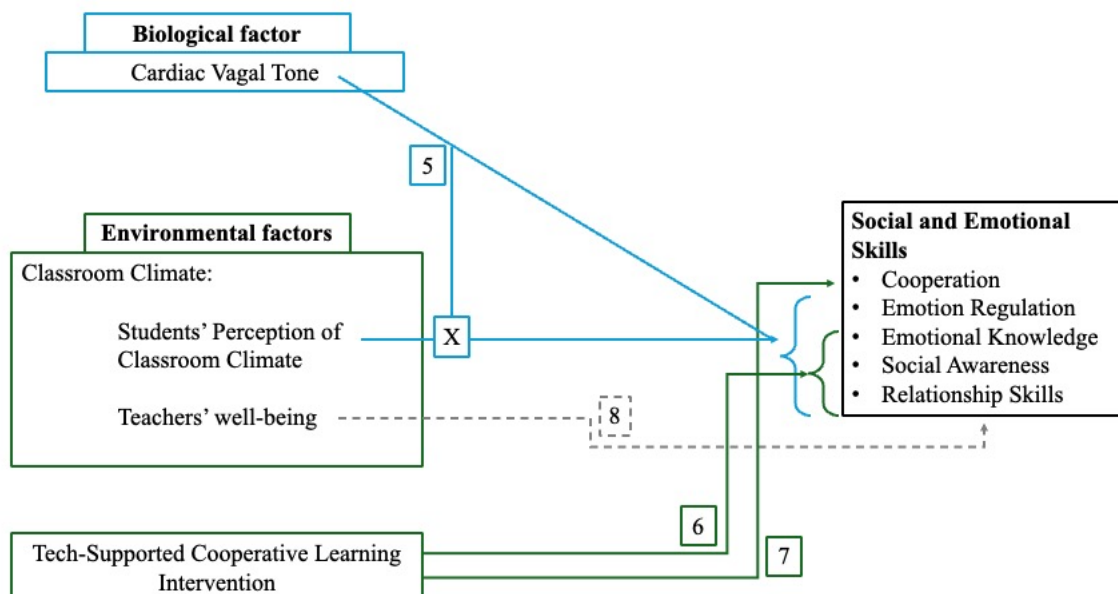
Chapter 4 | The Present PhD Project

4.1 Overview of the Studies

This dissertation aims to explore the development of social and emotional skills in school-age children from a biopsychosocial perspective. It specifically examines how biological and environmental factors, as well as their interactions, contribute to the development of key social-emotional abilities within the school context.

Using a cross-sectional approach centered on primary and middle school environments, this thesis aims to deepen understanding of how SES develops in the school context. It collectively investigates the links between children’s cardiac vagal tone, their perceptions of classroom climate, exposure to cooperative learning, and SES according to the five domains of the CASEL model. It also explores, as initial steps, teacher-related traits related to teachers’ well-being as the primary foundation for SES development.

Figure 3 – The Biopsychosocial Model Tested in the Present PhD Project



Note: Numbers refer to the number of Chapters.

Continuous lines represent the associations tested, while dashed lines represent assumed relationships that were not tested.

Figure 3 provides a schematic overview of the conceptual model underlying this dissertation. Solid lines represent the direct associations examined in the empirical chapters, whereas dashed lines indicate hypothesized relationships that are conceptually relevant but were not empirically tested.

To fulfill the primary research objectives, four studies were conducted and are outlined across five chapters. Each study is briefly introduced below to highlight its contribution to the overall research goals.

Chapter 5 examines the relationship between children's cardiac vagal tone, their perceptions of the classroom climate, and various SES domains, including emotional knowledge, emotional regulation, social awareness, and relationship skills, as measured by the validated WCSD-SECA self-report (Davidson et al., 2018). Eighty-three children (ages 8–11; $M_{age} = 9.22$, $SD = 0.72$; 51 males, 37 females) completed self-reports on SES and classroom climate, while CVT was measured through resting electrocardiogram. The results aim to elucidate how CVT and perceived classroom experiences jointly influence children's social-emotional development.

Chapter 6 and 7 refer to two studies conducted on the same sample aimed at testing the effects of tech-supported CL intervention on SES. Specifically, the experimental group used PeerLearning.net software for the school year with the aim of improving students' SES. Chapter 6 examines the environmental aspect by evaluating how cooperative learning methods influence behavioral cooperation. The research included 36 classes, comprising 18 in the target group and 18 in the control group, with 307 students in the control group ($M_{age} = 9.48$, $SD = 0.79$) and 270 students in the experimental group ($M_{age} = 9.63$, $SD = 0.79$). The study investigated whether participation in structured CL activities correlates with increased cooperation levels, assessed through a behavioral task, an adapted digital version of The Marble Pull Game (Madsen, 1971).

Chapter 7 also examines the effects of CL, particularly on emotional knowledge, social awareness, and relationship skills. This research used the same sample as Chapter 6, consisting of 36 classes —18 for the target group and 18 for the control group — totaling 307 students in the control

group ($M_{\text{age}} = 9.48$, $SD = 0.79$) and 270 students in the experimental group ($M_{\text{age}} = 9.63$, $SD = 0.79$). SES was consistently measured using the WCSD-SECA self-report (Davidson et al., 2018).

Chapter 8 focuses on teachers' well-being, examining a national sample ($N = 1904$) and presenting recent data on burnout levels. Although the study did not directly assess the connection to student SES due to data limitations, it highlights high levels of teacher stress and psychological strain. These results emphasize the critical role of teacher wellbeing as a contextual factor influencing the socio-emotional environment of classrooms and, ultimately, students' developmental success.

Together, these studies provide a comprehensive understanding of how biological and environmental factors impact SES in school-age children. The findings have important practical implications for educational policy, offering guidance on how to foster SES development in an integrated classroom practice. They also provide helpful directions for teacher educators seeking to prepare professionals capable of recognizing and supporting students' socio-emotional growth, as well as for future research aimed at developing effective, biopsychosocially grounded school-based practices.

Chapter 5 | Building Social-Emotional Skills: Self-Regulation and Classroom

Climate in Primary Schools

Zagni, B., Van Ryzin, M., Ianes, D., & Scrimin, S. (2025). Building social-emotional skills: self-regulation and classroom climate in primary schools. *European Journal of Developmental Psychology*, 1-18.

<https://doi.org/10.1080/17405629.2025.2542849>

5.1 Theoretical Background

Following the bio-psycho-social model, the first study of my project aimed to investigate the direct and interactive role of biological and environmental factors in relation to social and emotional skills. Social and emotional skills in the classroom are a set of interrelated competencies that enable individuals to recognize and manage their emotions, establish and maintain healthy relationships, make responsible decisions, and navigate social environments effectively. These skills align with the five core domains outlined by the Collaborative for Academic, Social, and Emotional Learning (Collaborative for Academic, Social, and Emotional Learning CASEL, 2013): self-awareness, self-management, social awareness, relationship skills, and responsible decision-making (CASEL, 2013). According to CASEL, SES includes the ability to identify and regulate one's emotions (self-awareness, self-management), understand and empathize with others (social awareness), communicate effectively and resolve conflicts (relationship skills), and make ethical, constructive choices in various contexts (responsible decision-making). These competencies are central to social and emotional functioning and serve as a foundation for academic and personal success (Durlak et al., 2011, 2015; Taylor et al., 2017). Primary school is a critical period to foster SES, as children are at a developmental stage where cognitive, emotional, and social capacities are refined through practice and interactions outside the family environment, especially in the school context (Denham et al., 2015; Wigelsworth et al., 2020). Research demonstrates that fostering SES during this phase promotes adaptive outcomes across multiple domains, including improved academic performance,

enhanced peer relationships, and greater psychological resilience (Denham et al., 2015; Wigelsworth et al., 2020). For example, children with greater SES are better equipped to manage classroom demands, stay focused on tasks, and engage positively with their peers and teachers, which lays the groundwork for future success (Domitrovich et al., 2017; Payton et al., 2008). Conversely, deficits in these skills are associated with adverse outcomes such as behavioural problems, academic underachievement, and social difficulties such as peer conflicts, social isolation, or limited social support networks (Jones et al., 2015; Roeser et al., 2013). Furthermore, during primary school years, children undergo notable developmental changes in social and emotional skills, including improvements in self-regulation, social awareness, and relationship skills, as these competencies are shaped by increasing cognitive maturity and expanding social experiences (Denham et al., 2015; Eisenberg et al., 2010; Wigelsworth et al., 2020).

A Biopsychosocial Perspective: The Role of Cardiac Vagal Tone as an Index of Self-regulation

From a biopsychosocial perspective (Engel, 1997; Sameroff, 2010), development is influenced by a dynamic interplay of individual and environmental factors. Biologically, the regulation of emotions and social interactions is closely linked to the autonomic nervous system, with Cardiac Vagal Tone (CVT) serving as a key marker that underpins adaptive responses in social and environmental contexts (Appelhans & Luecken, 2006; Li et al., 2009; Porges, 2007; Thayer & Lane, 2000). CVT reflects the activity of the parasympathetic nervous system, primarily mediated by the vagus nerve, which plays a central role in regulating physiological responses to internal and external changes (Beauchaine, 2001; Berntson et al., 2008). It is conceptualized not as a socioemotional skill itself, but as a trait-like, neurobiological foundation that enables the effective regulation of behaviour and emotion – critical capacities that underlie social-emotional functioning (Eisenberg et al., 2010; Thayer & Lane, 2000). In this framework, CVT represents an individual difference variable that may influence how children respond to social environments, including classroom dynamics, and thus acts as a potential moderator of SES development. Indeed, resting CVT indicates the regulatory resources

available to a child when facing challenges. Elevated resting CVT reflects greater cardiac flexibility and system responsiveness, facilitating self-regulation and adaptive responses to environmental demands. While some developmental research suggests that resting CVT tends to increase with age throughout childhood, reflecting maturation of autonomic and self-regulatory systems (Beauchaine, 2001; Calkins & Keane, 2004), it is also considered a fairly stable individual trait, particularly when measured under standardized resting conditions (Berntson et al., 2008; Porges, 2007). This stability supports its widespread use as a marker of individual differences in physiological self-regulation, even in developmental samples. According to the neurovisceral integration model (Thayer & Lane, 2009), CVT serves as a marker of activity within a neural network that coordinates responses to environmental challenges, integrating cortical and subcortical structures through bidirectional vagal pathways. The polyvagal theory (Porges, 2003, 2007) also associates CVT with social connectedness (Geisler et al., 2013). Given the pivotal role of cardiac vagal activity in mediating interactions with and adaptations to the environment – encompassing both cognitive and social dimensions – its link to self-regulatory capacity in stressful contexts is well-documented (Calkins, 2007). This physiological marker has been consistently linked to key SES, including emotional regulation (Calkins & Keane, 2004; Porges, 2007) and positive relationship skills (Diamond & Cribbet, 2013; Geisler et al., 2013). In educational settings, children with higher CVT are better equipped to manage classroom stressors (such as academic tasks, social interactions, behavioural expectations, and emotional regulation challenges), delay gratification, and interact constructively with peers and teachers (Beauchaine, 2001; Diamond & Aspinwall, 2003; Mastromatteo et al., 2023). Moreover, CVT has been implicated in empathy and prosocial behaviour, as it enhances individuals' capacity to recognize and respond to others' emotional states (Stellar et al., 2015) as well as to cooperate with others (Mastromatteo et al., 2024; Zagni et al., 2024). Consequently, CVT may play a crucial role in shaping SES, as its regulation underpins the adaptive processes required to manage emotions, navigate social dynamics, and maintain positive interpersonal relationships. However, previous studies suggest that physiological self-regulation, such as CVT, may not independently predict social-

emotional outcomes; its influence often interacts with contextual and environmental factors, highlighting the importance of supportive conditions for optimal development (Hastings et al., 2008; Morris et al., 2017).

A Biopsychosocial Perspective: The Role of Classroom Climate

Indeed, the classroom environment also plays a crucial role in the development of SES. From a bio-psycho-social perspective (Bronfenbrenner, 1979), the classroom represents a proximal developmental context where children's social-emotional competencies are shaped through daily interactions with peers and teachers. Psychological theories also highlight the classroom's formative role: attachment-informed models emphasize the importance of secure teacher – student relationships for emotional regulation and social development (Hamre & Pianta, 2006), while social learning theory (Bandura & Walters, 1977) suggests that children internalize behavioural and emotional norms through observation and feedback in social environments. Moreover, emotion socialization theory posits that emotionally supportive climates provide critical scaffolding for learning self-regulation and prosocial behaviours (Eisenberg et al., 1998). Accordingly, classroom climate – as perceived by the child – may serve as a key mediator of developmental experiences relevant to social-emotional skill formation (Reyes et al., 2012). Classroom climate is characterized by the quality of social and emotional interactions both between and among students and teachers (Wilson et al., 2007). The dimension to which teachers and students form a harmonious microsystem through a high number of positive socio-emotional interactions defines the climate within the classroom. Classrooms where a positive climate is present diminish stress levels and contribute to building a harmonious and warm atmosphere (Hamre & Pianta, 2006). On the other hand, when a hostile classroom environment is experienced, students learn to be alert when specific situations arise (Scrimin et al., 2019), making it hard to engage in social and cognitive tasks efficiently (Scrimin et al., 2016). While the perception of such stressors may vary according to a child's age and stage of development, our approach conceptualizes these stressors in a general sense as situational demands requiring emotional and

behavioural regulation. Empirical evidence suggests that children's perception of a positive classroom climate is linked to better learning performance (Reyes et al., 2012) and increased motivation, emotion regulation skills, and well-being (Kochanska et al. 2000; Pianta et al. 2002). Children's subjective perceptions of classroom climate are critical, as individual differences in environmental sensitivity can impact how students interpret and respond to social and emotional challenges in school and, in turn, how they deal with required tasks (Scrimin et al., 2023). Research indicates that a positive perception of classroom climate – characterized by supportive teacher-student relationships, fairness, and collaboration among peers – is associated with stronger SES development, including enhanced emotional regulation, empathy, and interpersonal skills (Jennings & Greenberg, 2009; Virtanen et al., 2019). For instance, when students perceive their classroom as inclusive and emotionally secure, they are more likely to engage in prosocial behaviours, take risks in learning, and seek help when needed (Mitchell & Bradshaw, 2013; Roeser et al., 2013). Conversely, perceptions of an adverse classroom climate – marked by conflict, exclusion, or unpredictability – can hinder the development of SES, leading to increased stress and maladaptive behaviours (Hoglund & Leadbeater, 2004). This is particularly relevant in primary education, where children are highly sensitive to environmental cues and rely on positive classroom dynamics to support their emerging social and emotional competencies (Jennings & Greenberg, 2009). Thus, a positive climate creates the foundation for social and emotional skills to be effectively built and sustained.

Interaction Between CVT and Classroom Climate: Missing But Critical

Despite the well-established significance of SES in educational and developmental contexts, empirical research exploring the specific links between SES and key factors such as CVT and children's perceptions of classroom climate remains limited. Consequently, this study addresses these gaps by investigating the interplay between SES, physiological self-regulation as measured by CVT, and children's subjective evaluations of their classroom environment, providing novel insights into the biopsychosocial mechanisms underpinning these relationships. Understanding how these factors

interact to influence social and emotional skills not only provides new scientific insights but also has practical implications for teachers and educators. Methodologically, this study responds to ongoing critiques in the literature regarding the overreliance on self-report data in SES research (Crowder et al., 2019; Denham et al., 2015), by employing a multi-method approach that integrates biological, psychological, and environmental data. Specifically, the use of cardiac vagal tone as a physiological indicator of self-regulation allows us to capture an objective, behavioural marker that is less prone to self-report bias and complements children's subjective perceptions of classroom experiences. This design aligns with recent recommendations to adopt multi-level, ecologically valid assessments in the study of children's socio-emotional development (Domitrovich et al., 2017; Eisenberg et al., 2010). Thus, this study explored the direct and interactive effects of physiological self-regulation, as indexed by CVT, and the perception of classroom climate on social and emotional skills among primary school students. While we did not model age in relation to CVT or classroom climate directly, including age as a covariate in the prediction of SES allowed us to control for potential developmental influences on the outcome variable, thereby reducing the risk that observed effects were confounded by age-related variation in SES. Specifically, we addressed three separate but intertwined research questions.

RQ1: Does CVT have a direct effect on students' SES? We expected higher CVT to be linked to better SES in classroom settings (Beauchaine, 2015; Porges, 2007; Thayer & Lane, 2000).

RQ2: Does perceived classroom climate directly affect students' SES? Previous research suggests that the perception of a positive classroom environment enhances socio-emotional development by fostering a sense of safety, positive peer interactions, and student engagement (Hamre & Pianta, 2006, Jennings & Greenberg, 2009; Reyes et al., 2012).

RQ3: Do perceived classroom climate and CVT interact in predicting SES? We aimed to test the effect of the interaction between CVT and classroom climate since classroom-related SES development is shaped by intrinsic and extrinsic factors, which are unlikely to operate independently. Previous studies suggest that physiological self-regulation (e.g., CVT) alone may not consistently

predict social-emotional outcomes; its effects may depend on supportive environmental conditions (Hastings et al., 2008; Morris et al., 2017).

5.2 Method

5.2.1 Participants and Procedure

Eighty-three primary school students were enrolled in the study (49 males, 34 females). Students were between 8 and 11 years of age ($M = 9.22$, $SD = 0.72$). The distribution by age was as follows: 8-year-olds = 13; 9-year-olds = 40; 10-year-olds = 29; 11-year-olds = 1. In this developmental stage (8–11) key prosocial and emotional competencies undergo significant refinement. Given that children may experience and interpret classroom-related demands differently depending on age, we statistically controlled for age in all analyses to account for potential developmental variability in both SES and physiological responses. As students were drawn from six different classrooms (4th and 5th grades), with classroom sizes ranging from 11 to 19 students, we examined whether the data showed evidence of clustering by classroom. An exploratory mixed effects model including classroom as a random intercept indicated that the variance explained at the classroom level was minimal ($SD = 0.07$), suggesting limited between-classroom effects on the outcome variable. The study received ethics approval from the Psychological Research Committee of the University of Padua (approval number 96-a). After obtaining parental informed consent, children were assessed collectively in their classrooms for the classroom climate and SES scales. The teacher was always present in the classroom while the experimenter read the items aloud and provided clarification examples when necessary. The children then responded independently to the questions. Then, in the following days, their electrocardiogram at rest while watching a relaxing video was registered individually for 5 minutes in a quiet room at the school in the morning. Before beginning the recording, the experimenter ensured the children were calm, creating a relaxed and welcoming atmosphere.

5.3 Measures

5.3.1 Social and Emotional Skills

We utilized 14 items from the Washoe County School District Social–Emotional Competency Assessment (WCSD-SECA; Davidson et al., 2018), which is well-validated for measuring social and emotional skills, particularly within the five core SEL domains as outlined by the Collaborative for Academic, Social, and Emotional Learning (Crowder et al., 2019; Gordon et al., 2022). The decision-making scale was excluded from this study because it was outside the specific focus of our research, which was situated within a broader investigation of cooperative learning among children. Our primary interest lies in examining social and emotional skills that are most directly relevant to the dynamics of cooperative learning, such as self-awareness, self-management, social awareness, and relationship skills. Example items included: ‘Knowing when my feelings are making it hard for me to focus’ (self-awareness), ‘Getting through something even when I feel frustrated’ (self-management), ‘Knowing what people may be feeling by the look on their face’ (social awareness), and ‘Getting along with my classmates’ (relationship skills). Students rated their perceived ease of managing emotions on a 4-point scale, from 1 (very difficult) to 4 (very easy), with higher scores indicating greater ease in social and emotional skills. The average score across these items was used as the primary measure of social and emotional skills. Cronbach’s alpha was .78.

5.3.2 Classroom Climate

Nine items were adapted from the Achievement domain of the CHIP-CE/CRF (Riley et al., 2004), originally composed of 15 items covering academic performance, peer relations, and work habits. The selected items focused specifically on classroom experiences, including relationships with

peers and teachers, attention, and emotional responses in the school setting. This scale captures students' perceptions of their classroom environment, focusing on factors such as the level of support from teachers, peer relationships, and the general sense of safety and belonging. Although children across the 8–11 age range completed the same classroom climate measure, previous research suggests that perceptions of classroom dynamics may vary with age (Pianta et al., 2002). While we did not directly analyse the effects of age on classroom climate perception, age was controlled for in our SES analyses to account for developmental variability more broadly. A Principal Component Analysis (PCA) with varimax rotation was performed to identify the underlying dimensions of classroom climate, revealing a two-factor structure. The first factor (MR1) captured negative classroom experiences, including boredom and inattention. In contrast, the second factor (MR2) reflected supportive and relational aspects of classroom climate, including feeling understood by the teacher and getting along with classmates. Based on both theoretical alignment with our conceptualization of classroom climate and statistical quality, MR2 was retained for further analysis as our index of perceived classroom climate. To further examine the relationships among CHIP items and social-emotional skills indicators, a correlation matrix was produced using the *pairs.panels* function from the *psych* package in R (Revelle, 2023). This analysis provided Pearson correlation coefficients, density plots, histograms, and significance levels, enabling a visual and statistical examination of inter-item associations. These exploratory analyses supported the construct validity of the MR2 composite. This composite score was computed as the mean of four items (only item 3 was not reversed): 1) 'How often does the teacher punish you?', 2) 'How often do you feel worried when you are in class?', 3) 'How often do you get along with your classmates?' and 4) 'How often do you argue with your classmates?'. Students responded to each item on a 5-point scale, ranging from 1 (never) to 5 (always), with higher scores indicating a more positive classroom climate. The average of the four items was our measure of perception of classroom climate in this study. Cronbach's alpha was .72.

5.3.3 Cardiac Vagal Tone

Cardiac vagal tone, indexed by heart rate variability, was recorded at rest for five minutes while the children watched a relaxing video to help maintain a calm state. A POLAR sensor, positioned on a band at chest level in direct contact with the participant's skin, was used to continuously record the ECG signal. This signal was converted from 12 bits to 256 samples per second using a ProComp Infiniti converter (Thought Technology, Montreal, Canada) and transmitted to Biograph Infiniti software for processing. The signal was then exported to Kubios HRV software (version 2.2, Kuopio, Finland) for further analysis. Within Kubios, inter-beat intervals (IBIs) were calculated by measuring the millisecond difference between successive R waves in the ECG data. After visual inspection and signal cleaning to remove any artefacts, the root mean square of successive differences (rMSSD) was computed. rMSSD is a well-established time-domain measure of heart rate variability and reflects parasympathetic (vagal) activity, revealing the extent of vagus nerve influence on the heart at rest (Berntson et al., 1997; Porges, 2007). High rMSSD values indicate more excellent vagal tone, associated with better physiological self-regulation and adaptive responses to environmental demands.

5.4 Results

The data analysis was conducted using RStudio (Version 2024.09.1 + 394; Posit Software, PBC, 2024). Descriptive statistics and correlations are presented in Table 2. A two-step linear regression analysis was conducted while controlling for age to test the direct and interactive effects of CVT and perception of classroom climate on classroom-related SES. The interaction term was computed using the product of the two centered predictors (Aiken & West, 1991). In the first step of the regression analysis, the direct effect of CVT, indexed by RMSSD, on SES was tested. The results did not indicate a significant main effect of CVT in the first step of the model ($B = .10, p = .247$). However, as shown in Table 3, a significant positive main effect of the perception of classroom

climate on SES ($B = .30, p < .001$) was found, meaning that students who perceived a more positive classroom environment reported stronger social and emotional skills. To examine the third research question, the interactive effect of perceived classroom climate and CVT on SES was assessed in the second step of the regression model. As shown in Table 3, results revealed a significant interaction effect ($B = .27, p = .031$). A simple slope analysis was conducted to clarify further this interaction (see Figure 4). SES increased significantly in more positive perceived classroom climates for students with high CVT (indicating greater physiological self-regulation). Conversely, for students with low CVT, the perception of classroom climate had a weaker or nonsignificant impact on their SES development.

Table 2 – Descriptive Statistics and Correlations

	<i>Descriptives</i>				<i>Cronbach's alpha</i>	<i>Correlations</i>	
	<i>M</i>	<i>SD</i>	<i>min</i>	<i>max</i>		<i>Classroom climate</i>	<i>Social and emotional skills</i>
<i>Social and emotional skills</i>	2.68	0.45	1.65	4.0	.78	.41***	-
<i>Classroom climate</i>	3.74	0.64	1,25	4.75	.72	-	-
<i>CVT</i>	62.70	39.20	21.33	260.58		-.05	.10

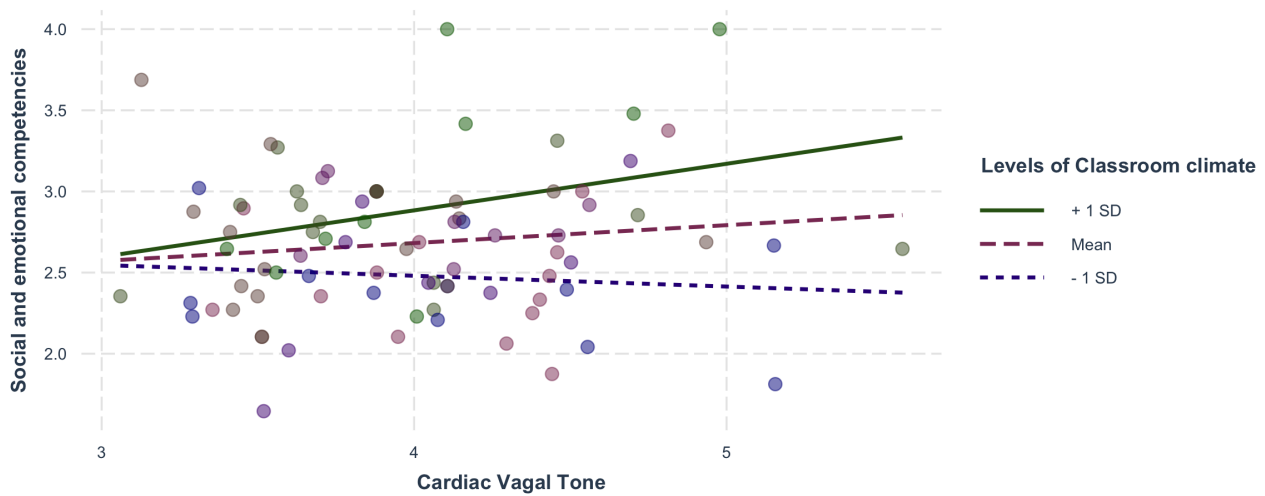
* = $p < .05$, ** = $p < .01$, *** = $p < .001$

Table 3 – ANOVA Table Model for the Direct Effects and the Interaction of CVT and Perception of Classroom Climate, Controlling for Age.

Social and emotional skills

<i>Predictors</i>	<i>First step</i>			<i>Second step</i>		
	<i>Estimates</i>	<i>CI</i>	<i>p</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	0.78	- 0.74 – 2.30	0.309	4.79	0.87 – 8.71	0.017
Rmssd log (CVT)	0.10	-0.07 – 0.28	0.247	-0.92	-1.86 – 0.02	0.056
Classroom climate	0.30	0.15 – 0.44	<0.001	-0.79	-1.77 – 0.20	0.118
age	0.04	-0.09 – 0.17	0.528	0.04	-0.08 – 0.17	0.402
Rmssd log (CVT) x Classroom climate	-	-	-	0.28	0.03 – 0.52	0.031
Observations	83			83		
R ² / R ² adjusted	0.187 / 0.156			0.234 / 0.195		

Figure 4 – Effects of Social and Emotional Skills by the Interaction Between Cardiac Vagal Tone and Perception of Classroom Climate



5.5 Discussion

The present study aimed to examine the individual and interactive effects of children’s physiological self-regulation, as indexed by cardiac vagal tone, and their perception of classroom climate on social and emotional skills. Indeed, we tested whether CVT and classroom climate independently predicted SES, and whether CVT moderated the association between perceived classroom climate and SES. These findings align with a biopsychosocial and ecological view of development, highlighting how internal self-regulation (e.g., CVT) and environmental experiences (e.g., classroom climate) interact to support or hinder the growth of social-emotional skills.

Specifically, CVT alone was not directly associated with school-related SES. This finding suggests that physiological self-regulation capacity indexed by CVT cannot explain SES independently of the classroom context. This may be due to the nature of our measure of SES in this study, which focused on the classroom context; external environmental factors, such as teacher-student relationships and peer interactions, may have played a more prominent role than intrinsic physiological regulation alone. Similar findings have been reported in studies where CVT was not directly associated with specific social-emotional outcomes but played a moderating role in

supportive environments (Gentzler et al., 2013; Hastings et al., 2008). Although CVT is a well-established indicator of physiological readiness for adaptation and emotional regulation (Porges, 2007; Thayer & Lane, 2000), its limited direct impact on SES highlights the importance of environmental and contextual factors in shaping these competencies. The school context introduces multiple layers of complexity – peer interactions, teacher expectations, and academic demands – that may shape SES development in ways physiological markers alone cannot explain (Beauchaine, 2015).

Regarding the second research question, the findings reveal that a positive perceived classroom climate had a significant direct effect on students' school-related SES for this sample, supporting the idea that an emotionally supportive and safe classroom environment is essential to foster these competencies. This aligns with previous research suggesting that when students perceive their classroom as a safe and supportive space, they are better able to develop social awareness, relationship skills, and emotional regulation (Hamre & Pianta, 2006, Jennings & Greenberg, 2009; Reyes et al., 2012; Virtanen et al., 2019). It is important to note that children's perceptions of the classroom environment may vary with age, as older students generally have more developed cognitive and emotional capacities to assess social dynamics (Mitchell & Bradshaw, 2013; Pianta et al., 2002). However, interpreting the direct effect requires caution, as the significant interaction between CVT and the perception of classroom climate provides further insights, also in line with the bio-psycho-social approach (Bronfenbrenner, 1979; Sameroff, 2010).

A positive classroom climate significantly enhanced SES for students with high CVT, suggesting that students physiologically predisposed to self-regulation benefit most from an emotionally supportive environment. These findings align with Porges (2003) which posits that vagal tone supports social engagement and emotional responses, particularly in supportive and safe contexts. A positive classroom climate may amplify the capacity of high-CVT students to engage socially, empathize, and form positive relationships by reducing stress and promoting feelings of safety and belonging (Hamre & Pianta, 2006). Additionally, the interactive effect highlights how

classroom environments serve as a scaffold for socio-emotional competencies. High- CVT students will likely utilize this supportive environment to practice adaptive behaviours, such as conflict resolution and collaborative learning, thereby further enhancing their SES outcomes (Reyes et al., 2012). Conversely, for students with lower CVT, their limited physiological capacity for self-regulation may hinder their ability to benefit from even the most supportive classroom climates. This highlights the need to prioritize strengthening CVT as a foundational step, ensuring students are better equipped to adapt to and leverage environmental supports for developing social and emotional skills (Laborde et al., 2018; Porges, 2007; Thayer & Lane, 2000). For these students, the perception of supportive classroom climates alone may not fully compensate for CVT-related challenges in developing SES. Additional challenges, such as higher baseline stress or reduced attention control, may exacerbate their difficulty in utilizing classroom resources effectively (Eisenberg et al., 2010). Therefore, while a supportive classroom climate can mitigate external stressors, it may not fully compensate for their physiological self-regulation deficits.

These results have important implications for educational practice. First, it is essential to prioritize enhancing students' physiological self-regulation capacities (e.g., through mindfulness, physical activity, and stress-management strategies), such as CVT, as a prerequisite for effectively benefiting from a positive classroom climate (Bluth et al., 2015; Domitrovich et al., 2017; Mendelson et al., 2010). Once students are equipped with these foundational self-regulation skills, fostering a supportive classroom climate becomes crucial to providing the social and emotional scaffolding necessary for translating these capacities into effective SES. Evidence-based SEL programs that integrate individual self-regulation, and environmental supports can help bridge the gap for students with lower CVT, promoting inclusive environments that support SES development for all students (Low & Van Ryzin, 2024; Weissberg et al., 2015).

5.6 Conclusions and Limitations

This study – in line with the bio-psycho-social approach adopted – highlights the interplay between biological and environmental factors in shaping social and emotional skills. However, relying on self-reported measures in this age group introduces potential biases, as younger children may have limited self-awareness and may be influenced by social desirability or misunderstanding of the questions (Rosenman et al., 2011). Additionally, as all key measures were collected from the same informants (the children), the study is potentially subject to single-informant bias. Future research would benefit from incorporating teacher, peer, or observational data to strengthen construct validity. Furthermore, the cross-sectional design limits causal interpretations, and future research should explore these dynamics longitudinally, particularly during critical developmental stages like adolescence (Eisenberg et al., 2010; Perry et al., 2018). Examining other physiological markers and diverse environmental factors, such as family and peer influences, could further clarify the factors shaping SES. Another limitation of the current study is that we did not directly examine the role of age in relation to CVT or perceptions of classroom climate. Although age was included as a covariate in our models predicting SES, this statistical control primarily accounts for developmental variability in the outcome variable (SES) rather than exploring how age may shape the predictor variables themselves. Prior research suggests that both physiological regulation (e.g., CVT) and children's interpretations of classroom environments can change with age (Beauchaine, 2001; Pianta et al., 2002). Future studies could build on our findings by explicitly modelling age-related effects on CVT and classroom climate perceptions, or by using age-stratified analyses to explore potential developmental differences in the mechanisms underlying SES. Finally, although children were nested within classrooms, the number of participants per class was too limited to allow for reliable multilevel modelling. Although we tested the influence of between-classroom variance, this remains a significant limitation, as classroom-level factors may have also influenced children's perceptions of climate and their SES outcomes. Future research should address this by recruiting larger class-based samples to account for nested data structures adequately. Overall, school-based research often

involves practical trade-offs, including limited sample sizes and time constraints for data collection, which reduce the feasibility of testing more complex models with multiple interacting variables.

In conclusion, this study highlights the bio-psycho-social nature of SES, showing how the interaction of physiological regulation and environmental support can shape their development. While a positive classroom climate may be able to provide some benefit to all students, those with greater physiological self-regulation capacity appear to be able to leverage these environments most effectively. For students with lower CVT, targeted interventions alongside supportive classroom practices may be necessary to promote equitable opportunities for SES development. Integrated interventions targeting physiological readiness and classroom support may provide more comprehensive strategies to enhance SES in all students.

Chapter 6 | Advancing Social and Emotional Skills through Tech-Supported Cooperative Learning in Primary and Middle Schools

Zagni, B., Van Ryzin, M., Ianes, D., & Scrimin, S. (2025). Advancing Social and Emotional Skills Through Tech-Supported Cooperative Learning in Primary and Middle Schools. *European Journal of Education*, 60(3), e70166. <https://doi.org/10.1111/ejed.70166>

6.1 Theoretical Background

The second study addressed, by means of an intervention, the importance of modifying the environment to support SES in students. Specifically, a Cooperative Learning intervention was implemented in 18 classrooms over the course of a school year to increase cooperative interactions between students and improve student-teacher relationships through positive and structured feedback. This was possible thanks to the use of tech-supported software, which will be discussed further on.

Indeed, one of the ways to develop SES in schools is through Cooperative Learning as a teaching method that naturally integrates a focus on social and emotional skills development. Indeed, in the classroom, students must not only learn but also be able to regulate their emotions and engage in complex social interactions. As educational settings become increasingly diverse and more cognitively and socially demanding, Social and Emotional Skills (SES) emerge as essential competencies that enable students to navigate these challenges effectively (Durlak et al., 2011; Taylor et al., 2017). Indeed, these skills are fundamental for fostering adaptive behaviors, strengthening peer relationships, and promoting psychological well-being, thereby contributing to academic success and long-term personal development (Denham et al., 2012; Jones et al., 2015). SES are deeply interconnected with cognitive and behavioral development, influencing academic achievement, psychological resilience, interpersonal relationships, and overall life satisfaction (Denham et al., 2012; Jones et al., 2015). Moreover, SES are critical for academic engagement and classroom behaviour (Durlak et al., 2011; Taylor et al., 2017). Research consistently demonstrates that strong SES contribute to higher academic performance, improved peer relationships, and greater emotional

resilience (Domitrovich et al., 2017; Payton et al., 2008), whereas deficits in these areas can lead to behavioural problems, social isolation, and academic underachievement (Jones et al., 2015). SES encompass a broad range of abilities that support self-regulation, social adaptability, and responsible decision-making, all of which contribute to students' capacity to learn effectively and participate constructively in the school community (Denham et al., 2012; Jones et al., 2015). The Collaborative for Academic, Social, and Emotional Learning (CASEL 2012, 2020) provides a widely accepted framework for understanding SES, identifying five core competencies essential for social and academic success: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making. These competencies are particularly crucial in primary and middle school, where students experience significant cognitive, emotional, and social transitions (Wigelsworth et al., 2016). The heightened emotional reactivity and salience of social stimuli that characterise adolescence (Casey et al., 2008) make social–emotional skills a very relevant tool for youths to navigate the complex requests and choices of their daily lives. Hence, improving these skills at an early age, in late childhood and early adolescence, can be promising in preventing later problems. During these years, children and pre-adolescents should actively acquire, refine, and practice SES through daily interactions with peers and teachers, including both structured and informal learning experiences. Schools play a central role in this process by providing environments where students can repeatedly apply and reinforce these competencies in real-world contexts, fostering immediate social–emotional growth and long-term personal development (Domitrovich et al., 2017; Taylor et al., 2017). Given their fundamental role in personal and academic development, there is a strong rationale for embedding SES instruction within school curricula as early as possible, rather than postponing interventions until the later school years when challenges may already be more difficult to address (Domitrovich et al., 2017; Weissberg, 2019). One of the most common approaches to fostering SES in educational settings is through Social and Emotional Learning (SEL) programs, which have been widely implemented in schools worldwide, demonstrating significant benefits, including improved emotional regulation, increased academic performance, and reduced behavioural

issues (Durlak et al., 2011; Taylor et al., 2017). Despite their proven benefits, integrating SEL programs into schools remains a challenge, particularly in Italy, where they are relatively unknown, and the development of socioemotional skills is often left to the individual teacher's initiative. Teachers often complain that they must carry out their subjects' programs and focus on learning the content. Therefore, choosing a specific teaching methodology allows them to consider integrating SES directly into the content (for more on this, see the current evidence-informed education, Dell'Anna et al., 2023; Vivonet, 2013). Indeed, while SEL programs traditionally involve direct instruction and teacher-led activities, emerging research suggests that integrating SES development into broader pedagogical approaches, such as Cooperative Learning (CL), can be equally, if not more, effective (Domitrovich et al., 2017; Low and Van Ryzin, 2024). CL is an instructional approach in which students work collaboratively in small groups to achieve shared learning goals. Cooperative learning enables the teacher to shift away from the traditional lecture-based approach, fostering a more student-centered and interactive learning environment (Johnson & Johnson, 2009). This, in turn, allows the teacher to focus more on teaching SES, as they are relieved from the demands of direct content instruction (Buchs et al., 2017; Van Ryzin & Roseth, 2019a, 2019b). Research suggests that CL is one of the most effective ways to enhance SES, as it provides authentic contexts for practicing interpersonal skills, communication, and conflict resolution (Johnson & Johnson, 2009; Van Ryzin & Roseth, 2019a, 2019b). When students engage in structured, interdependent tasks, they develop self-regulation, empathy, and teamwork skills, key components of SES (Domitrovich et al., 2017; Low & Van Ryzin, 2024). However, CL is most effective when structured according to well-established design principles, including positive interdependence, individual accountability, explicit development of social skills, and structured group processing (Johnson et al., 2013). Nevertheless, ensuring fidelity to these principles in classroom practice is challenging as it requires meticulous planning, structured facilitation, and continuous monitoring of group dynamics. Research indicates that teachers often struggle to implement CL effectively due to time constraints, difficulty managing group interactions, and a lack of understanding of key design principles (Abrami et al., 2004; Buchs et al., 2017; Gillies

& Boyle, 2010). When these elements are inconsistently applied or omitted, the benefits of CL, such as improved social–emotional skills, academic performance, and peer relations, are significantly diminished (McMaster & Fuchs, 2002; Roseth et al., 2008). Indeed, technology-supported solutions have been developed to facilitate the implementation of CL while maintaining fidelity to evidence-based practices (Low & Van Ryzin, 2024). One web-based platform, PeerLearning.net, assists teachers in structuring CL lessons by automating group formation, integrating instructional materials, guiding collaborative skill development, and streamlining post-lesson group processing. By reducing the logistical and practical burden on teachers, technology-enhanced CL ensures that students fully engage in collaborative interactions that foster both academic learning and the development of social–emotional competencies (Van Ryzin & Roseth, 2019a, 2019b; Van Ryzin et al., 2020). For example, a recent cluster-randomised trial found that student-centered, technology-supported CL environments significantly improved students' social–emotional competencies, peer relationships, and mental health (Low & Van Ryzin, 2024; Zagni & Van Ryzin, 2024). Low and Van Ryzin (2024) conducted a cluster-randomized trial involving 813 students from 12 middle and high schools in the Pacific Northwest. The study examined the effects of technology-assisted CL on five social–emotional competencies and social and behavioural outcomes. The intervention group utilised technology-supported CL, while the control schools maintained regular instruction. After 1-year, significant improvements were found across all measured social–emotional competencies and social-behavioural outcomes, with moderate to large effect sizes. Similar results have been found by Zagni and Van Ryzin (2024). The findings indicated that implementing CL significantly improved peer relations and reduced victimisation and mental health problems, with moderate to large effect sizes observed across different demographics. Positive peer relations significantly predicted lower victimisation and improved mental health, highlighting the potential of technology-supported CL in addressing adolescent mental health by enhancing protective factors and reducing risks (Zagni & Van Ryzin, 2024). Existing research has mainly focused on high school students. This is particularly notable, given the importance of developing socio-emotional skills at an early age (Wigelsworth et al.,

2016). Furthermore, most existing research on SES interventions has focused on adolescents, emphasising remediation rather than prevention. Studies have shown that addressing SES development before adolescence, when social habits and emotional regulation patterns become more ingrained, can help mitigate later risks such as behavioural issues, school disengagement, and mental health challenges (Jones et al., 2015). Strengthening these skills early on might represent a proactive strategy to reduce long-term social and emotional difficulties. In addition, research has been primarily conducted in the United States. However, educational practices and school systems differ significantly in Europe, particularly in Mediterranean countries. Hence, there is a need to test CL within these cultural contexts. This study aimed to address this gap by examining the effectiveness of PeerLearning.net in supporting Cooperative Learning among primary and middle school students in Italy¹. Specifically, the research investigated whether technology-enhanced CL could promote social and emotional skill development in younger students, replicating findings from high school settings and extending the applicability of these interventions to diverse educational systems and cultural contexts. Based on existing evidence that structured CL fosters cognitive, social, and emotional skills (Johnson & Johnson, 2009; Van Ryzin & Roseth, 2019a, 2019b) and that technology-enhanced CL improves implementation fidelity and maximises benefits (Low & Van Ryzin, 2024), we hypothesised that students using PeerLearning.net will exhibit more significant improvements in SES compared to those in traditional instructional settings (control group).

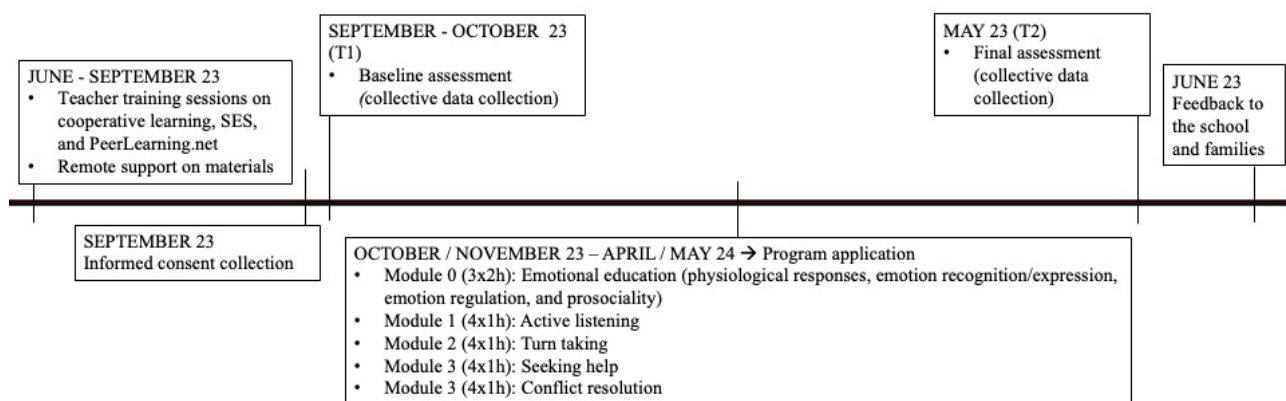
6.2 Materials and Method

6.2.1 Study Design and Procedure

This study involved multiple schools from northeastern Italy. To create a control and an intervention group, we gathered the schools' participation and randomly assigned 18 classes (from 3 schools) to the intervention group (Group 1) and 18 classes (from 4 schools) to the control group (Group 2). The control group received no intervention but was allowed to participate in the programme the following

year (waiting group). For the intervention group (for better visualisation and understanding of the training, see Figure 5), the initial phase consisted of two teacher training sessions on cooperative learning, SEL, and using PeerLearning.net. These sessions were conducted by the researcher (a psychologist, first author) and one research assistant and took place during the summer, prior to the start of the school year. Following the training, remote support was provided by sending reading materials and video tutorials to prepare teachers for the lessons². When school started, the intervention group participated in four classroom activities (Module 0, October–November) led by psychologists in each class, focusing on socio-emotional skills. This was followed by 16 cooperative learning lessons (on reading text comprehension) using the PeerLearning.net software, spaced throughout the school year (November–May). During the first lesson, the researcher assisted with the teaching process through job shadowing, gradually allowing the teachers more autonomy as the program progressed. Only Italian language teachers were involved due to the content focus (text comprehension), and support teachers (where present) were also involved. Data collection took place for both groups at the beginning and end of the academic year. The study received ethical committee approval (code 96-a), and informed consent was obtained from the parents. Data collection took place in the classroom, with the experimenter reading and explaining the items to the students to avoid reading difficulties or cognitive challenges that might have compromised the data quality.

Figure 5 – Overview and Timeline of the Intervention Group Program



6.2.2 Participants

Initially, 607 students participated in the study, with 324 students in the experimental group and 283 in the control group at Time 1 (pre-test). At Time 2 (post-test), 314 students remained in the experimental group and 274 in the control group. However, only students who were present at both time points were included in the final analysis to ensure consistency in the measurement process. As a result, the final dataset consisted of 307 students in Group 1 ($M_{age} = 9.48$, $SD = 0.79$) and 270 students in Group 2 ($M_{age} = 9.63$, $SD = 0.79$), with complete data available for both time points. The classes were equally distributed across both groups: eight fourth-grade, eight fifth grade, and two middle school classes. The students excluded from the final sample ($n = 34$ from the experimental group and $n = 11$ from the control group, totaling 45 students) were removed because they were

absent on the day of data collection at either Time 1 or Time 2 or due to school transfers during the academic year.

6.2.3 CL Intervention and SES Development

To foster socioemotional skills, we designed a structured training program comprising four modules. Each module comprised four lessons (16 lessons), during which the same socio-emotional skill was consistently practiced (see Figure 1). We focused on developing specific skills aligned with key dimensions of SEL (CASEL, 2020). Specifically, active listening in the first module supported the development of emotional knowledge by fostering students' ability to accurately perceive, interpret, and respond to verbal and nonverbal emotional cues in themselves and others (Weger et al., 2010). The second module, centered on turn-taking, reinforced social awareness by fostering an understanding of group dynamics, perspective-taking, and respect for others' rights in conversations and collaborative settings (Denham, 2006). The third module, which focused on giving and seeking help, strengthens relationship skills by promoting cooperative behaviours, empathy, and mutual support in peer interactions (Wentzel, 1999). Finally, the fourth module on conflict resolution integrated all these dimensions by requiring students to regulate their emotions, navigate social cues, and effectively communicate in challenging interpersonal situations (Jones, 2004). In the first lesson of each module, the researcher explicitly introduced and taught the targeted skill, followed by a class discussion involving the students. To support this process, the PeerLearning.net software provides a dedicated section for directly instructing socio-emotional skills as a first step. At this stage, example sentences are presented on the screen to show how social skills can be applied. This is followed by a phase in which the class collectively sets a behavioural goal. This goal establishes the expected frequency with which the teacher aims to observe the targeted socio-emotional behaviour within the classroom context (e.g., ten times). Following the principles of Positive Behaviour Support (Sugai & Horner, 2002), the teacher reinforced the students whenever they demonstrated verbal or non-verbal

behaviours aligned with the practiced skill, assigning one point to the group. The teacher's role is characterised by scaffolding (Wood et al., 1976), actively supporting skill development within Vygotsky's (1978) Zone of Proximal Development. In this framework, the teacher does not passively wait for competencies to emerge; instead, they strategically provide stimuli and guidance to facilitate their acquisition. Throughout the lesson, the teacher continuously monitored the application of the targeted skill. At the end of each lesson, the PeerLearning.net software includes a structured review phase, followed by a group processing session. In the review phase, students assessed their collective performance by reflecting on the score obtained and discussing the reasons behind their achievement. This is followed by an individual reflection on the cognitive content learned and the socio-emotional skill applied, which is discussed in a group setting. Indeed, the literature highlights that the group processing phase enhances socioemotional competencies (Johnson et al., 1994). Research indicates that structured reflection and peer discussion foster deeper learning, increase self-awareness, and improve interpersonal skills (Zins et al., 2004). Concerning the CL structures, three were selected to enhance student cooperation and engagement: group projects, group inquiry, and jigsaw (a lesson example is provided in Appendix 1). These structures³ were chosen based on their effectiveness in promoting peer interaction, shared responsibility, and deep learning (Van Ryzin & Roseth, 2019a). Group projects encourage students to work collectively toward a common goal, fostering accountability and interdependence. Specifically, Group Projects use task-based interdependence (each student has a unique task or tasks within the group). This method has been shown to improve social and academic skills by requiring students to coordinate efforts and engage in shared decision-making (Gillies, 2007). Group inquiry involves collaborative problem-solving and critical thinking, requiring students to actively construct knowledge together through planning, discussion, and synthesis of ideas. Practically, Group Inquiry uses role-based interdependence (each student has a unique role in the group). Finally, the jigsaw method enhances cooperative learning by assigning each student a unique piece of information that must be shared with peers to complete the task, thus

reinforcing interdependence and active participation. This technique has been widely recognised for improving comprehension and fostering positive peer interactions (Aronson & Patnoe, 2011).

6.2.4 Social and Emotional Skills Measure

We employed an adapted version of the WCSD Social and Emotional Competency Long-Form Assessment (Davidson et al., 2018), a widely validated tool designed to measure students' social and emotional skills. The WCSD Social and Emotional Competency Assessment is grounded in the CASEL framework, which identifies five core competencies: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making (CASEL, 2012). Our assessment did not include the Responsible Decision-Making subscale as it falls outside the specific social and emotional skills targeted in this study. Our focus was on core competencies related to Emotional Knowledge (EK), Emotional Regulation (ER), Social Awareness (SA), and Relationship Skills (RS), which are more directly relevant to the research objectives. Each item was rated on a four-point Likert scale, ranging from “Very Difficult” (1) to “Very Easy” (4), allowing for a nuanced assessment of participants' perceived socio-emotional competencies. Prior research has demonstrated the reliability and predictive validity of this instrument in educational and developmental contexts (Low & Van Ryzin, 2024), supporting its utility in assessing emotional and social skills in adolescent populations. Given that the scale has been widely used with adolescents but less frequently with children, we conducted a factor analysis to ensure its validity and appropriateness for this age group. To explore the underlying factor structure of the subscales, we conducted an exploratory factor analysis (EFA) using the psych package in R (Revelle, 2023). A two-factor solution (nfactors=2) with varimax rotation was applied to improve interpretability. The results indicate that MR1 is primarily associated with ER, showing a factor loading of 0.644, and with RS, which has a loading of 0.510. Meanwhile, MR2 is primarily associated with SA, with a loading of 0.582, and EK, which loads at 0.461; RS also contributes to this factor, with a loading of 0.411. Given this structure, we used MR2

as a single index, excluding ER. Cronbach's Alpha for the MR2 index, composed of EK, SA, and RS, was 0.63, indicating moderate internal consistency. Thus, the final questionnaire was divided into three subscales (see Appendix 2): Emotional Knowledge (Items 1–4) assessed the ability to recognise and understand one's own emotions; Social Awareness (Items 5–7) measured the ability to interpret others' emotions and understand social dynamics; Relationship Skills (Items 8–11) evaluated interpersonal abilities, such as managing emotions in social situations and interacting positively with others.

6.2.5 Data Analyses

All statistical analyses were conducted in R (Version 2025.05.0+496; RStudio Team, 2024). To address missing data in the original dataset, we used multiple imputations by chained equations (MICE; Van Buuren & Groothuis-Oudshoorn, 2011) with the mice package in R. This approach was selected because it provides a principled way to handle missing data under the assumption that the data are missing at random (MAR), thereby reducing bias and increasing the efficiency of the estimates. After importing and reorganising the original dataset, we transformed it into a long format to facilitate longitudinal analyses. Demographic and key categorical variables (ID, class, group, time) were converted into factors. The imputation was performed on five replicated datasets ($m=5$), using the predictive mean matching (pmm) method to preserve the original data distribution. PMM was chosen because it ensures that imputed values are plausible by selecting observed values from similar cases, preserving the distribution, and avoiding unrealistic imputed data points. Categorical variables with too many levels (ID and class) were excluded from the predictive model to avoid computational overload. The imputed datasets were saved separately for analyses and the two measurement time points. This imputed dataset was subsequently used in a linear mixed-effects regression model to assess the effect of time, group, and other predictive variables on the target index. A linear mixed-effects model (LMM; Bates et al., 2015) was employed to examine the effects of time, group, and age

on the SES index (Social and Emotional Skills Index, see the Measures section). Linear mixed-effects models are particularly suited for this design because they account for the hierarchical structure of the data—repeated measures within students and students within classes—thus controlling for non-independence of observations and allowing for more accurate inference. Given the nested structure of the data, with observations clustered within individuals and individuals further nested within classes, the model included both fixed and random effects. Specifically, the fixed effects comprised time (two levels), group (two levels), and age (continuous variable), along with their interactions. The random effects accounted for individual variability (random intercept for ID) and class variability (random intercept for class). The model was specified as follows:

$$\begin{aligned}
 \text{Index_ESR_ijk} = & \beta_0 + \beta_1 \cdot \text{Time_i} + \beta_2 \cdot \text{Group_j} + \beta_3 \cdot \text{Age_ijk} \\
 & + \beta_4 \cdot (\text{Time_i} \times \text{Group_j}) \\
 & + \beta_5 \cdot (\text{Time_i} \times \text{Age_ijk}) \\
 & + \beta_6 \cdot (\text{Group_j} \times \text{Age_ijk}) \\
 & + \beta_7 \cdot (\text{Time_i} \times \text{Group_j} \times \text{Age_ijk}) \\
 & + u_k + v_jk + \varepsilon_ijk
 \end{aligned}$$

Where:

- β_0 is the fixed intercept,
- β_1 to β_7 are fixed effect coefficients for main effects and interactions,
- $u_k \sim N(0, \sigma^2_{\text{class}})$ is the random intercept for class,
- $v_{jk} \sim N(0, \sigma^2_{\text{ID}})$ is the random intercept for individuals,
- $\varepsilon_{ijk} \sim N(0, \sigma^2)$ is the residual error term.

The model was estimated using Restricted Maximum Likelihood (REML), ensuring robust variance estimates while handling the hierarchical nature of the data. Indeed, REML was preferred over maximum likelihood (ML) because it provides unbiased estimates of variance components, especially in models with small to moderate sample sizes or complex random effects structures.

A key aspect of the analysis was testing the interaction effect between time and group to assess whether changes in the SES index over time differed between groups. To determine the significance of this interaction, a likelihood ratio test was conducted by comparing the entire model, including the time \times group interaction term, with a null model that excluded this interaction. If the likelihood ratio test yielded a statistically significant result ($p < 0.05$), the interaction would be considered meaningful, indicating that group membership influenced the trajectories of the SES index over time. Following model estimation, estimated marginal means (EMMs; Lenth, 2023) were computed to facilitate the interpretation of effects, particularly for the time \times group interaction. These post-hoc comparisons allowed a more precise understanding of whether specific groups exhibited significant changes in the SES index across time points. Given the multiple comparisons involved, Bonferroni adjustments were applied to control for Type I error inflation.

6.3 Results

The results of the linear mixed-effects model (presented in Table 4) revealed important findings regarding the effects of time (beginning and end of the school year), group (1-intervention and 2-control), and their interaction on the SES index.

First, there was a significant main effect of time, indicating that, overall, SES index scores changed significantly between time points, $B = 0.07$, $SE = 0.03$, $t(574.04) = 2.72$, $p < .01$. This suggests that participants' social and emotional skills evolved, independent of group membership.

Second, the main effect of the group was not statistically significant, $B = 0.10$, $SE = 0.06$, $t(43.55) = 1.67$, $p = .10$, indicating that when averaged across time points, the two groups did not differ significantly in SES index scores. Similarly, the effect of age did not reach significance ($p > .05$), implying that age did not play a significant role in explaining the variance in SES index scores.

Crucially, the interaction between time and group was statistically significant, $B = -0.11$, $SE = 0.04$, $t(573.97) = -2.799$, $p < .01$ (see Figures 6 and 7 for a visual representation). This finding suggests that

the trajectory of SES index scores over time varied by group membership. Moreover, a likelihood ratio test was conducted to investigate this interaction further by comparing the complete model (including the interaction term) with a reduced model that excluded it. The comparison yielded a statistically significant result, $\chi^2(1) = 7.81, p < .01$, confirming that including the time \times group interaction significantly improved the model fit (see Table 5). Last, estimated marginal means (EMMs) were examined to interpret the interaction effect (presented in Table 6). The results indicated that for Group 1, SES index scores significantly increased from Time 1 to Time 2, $B = -0.07, SE = 0.03, t(580) = -2.716, p < .05$, suggesting an improvement in social and emotional skills. However, other pairwise comparisons, including differences between groups at specific time points, did not reach statistical significance ($p > .05$), indicating that changes were not uniform across all conditions.

Table 4 – Results of the Linear Mixed Model (REML) for Social and Emotional Skills

<i>Predictor</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>df</i>	<i>t value</i>	<i>p value</i>
<i>Intercept</i>	2.63	0.07	184.3	40.34	< .001 ***
<i>time2</i>	0.07	0.03	574.0	2.72	< .01 **
<i>group2</i>	0.10	0.06	43.5	1.67	.10
<i>age9</i>	0.05	0.06	554.2	0.84	.40
<i>age10</i>	0.03	0.06	403.5	0.46	.64
<i>age11</i>	-0.12	0.09	216.8	-1.34	.18
<i>time2 \times group2</i>	-0.11	0.04	573.9	-2.80	< .01 **

*Note: p < .001**, p < .01**, p < .05*.*

Table 5 – Comparison Between Full Model (with interaction between time and group) and Null Model (without interaction)

<i>Model</i>	<i>Parameters (npar)</i>	<i>AIC</i>	<i>BIC</i>	<i>LogLik</i>	<i>Deviance</i>	χ^2	<i>df</i>	<i>p value</i>
<i>Full</i>	9	1123.0	1168.2	-552.50	1105.0	-	-	-
<i>Null</i>	10	1117.2	1167.5	-548.59	1097.2	7.81	1	<.01 **

*Note: p < .001**, p < .01**, p < .05*.*

Table 6 – Estimated Marginal Means (EMMs) and Pairwise Contrasts for Group and Time Effects

<i>Contrast</i>	<i>Estimate</i>	<i>SE</i>	<i>df</i>	<i>t ratio</i>	<i>p value</i>
<i>time1 group1 - time2 group1</i>	-0.07	0.03	580.0	-2.72	<.05 *
<i>time1 group1 - time1 group2</i>	-0.10	0.06	43.7	-1.67	.62
<i>time1 group1 - time2 group2</i>	-0.06	0.06	43.9	-1.05	1.00
<i>time2 group1 - time2 group2</i>	-0.03	0.06	43.4	-0.45	1.00
<i>time2 group1 - time1 group2</i>	0.01	0.06	43.6	0.17	1.00
<i>time1 group2 - time2 group2</i>	0.04	0.03	579.9	1.29	1.00

Note: p-values are adjusted using Bonferroni correction.

Figure 6 – Interaction between Time and Group on Social and Emotional Skills

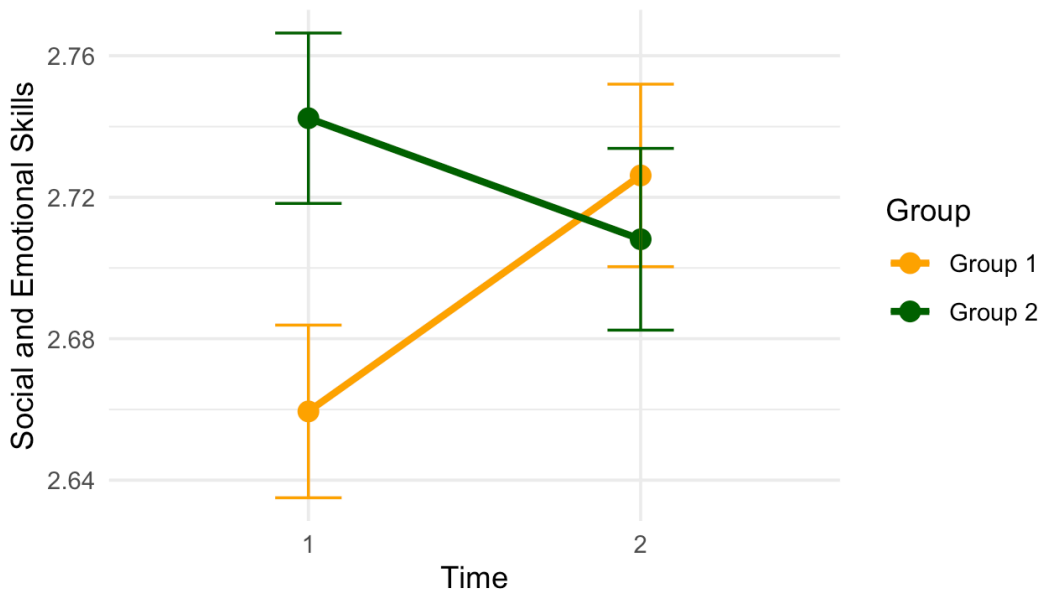
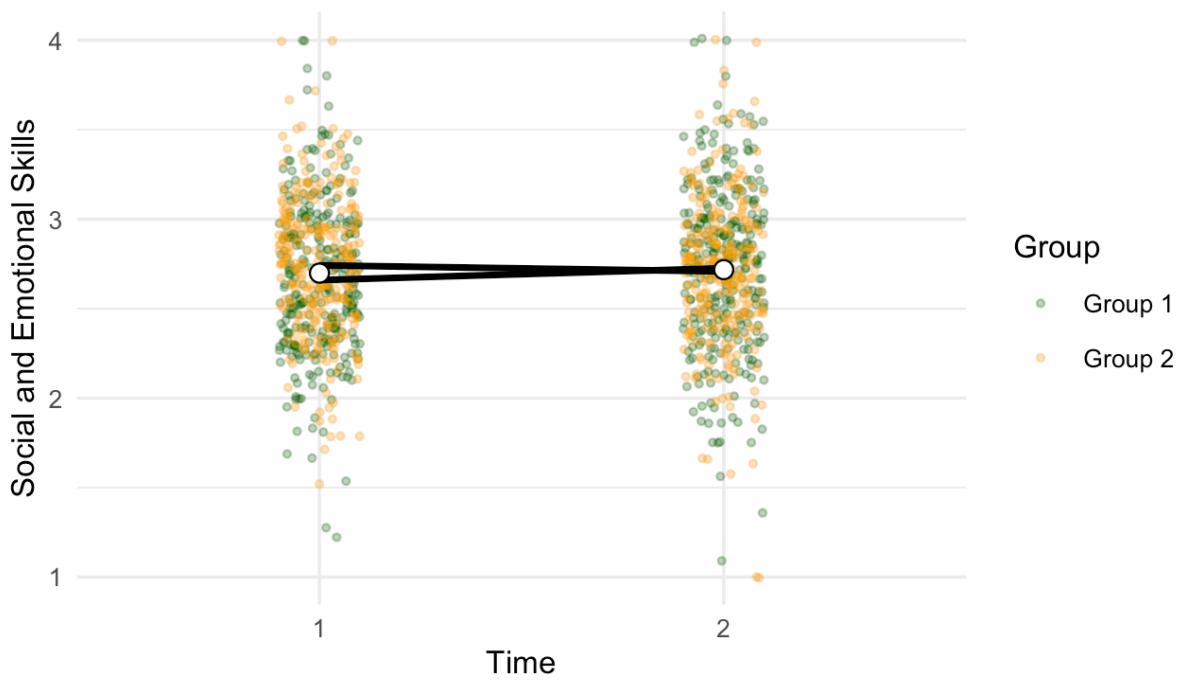


Figure 7 – Estimated Marginal Means and Confidence Intervals for the Interaction Between Time and Group on Social and Emotional Skills



6.4 Discussion

This study examined the impact of a structured, tech-supported (PeerLearning.net) CL program on students' social and emotional skills. The primary objective was to assess whether technology-supported CL could enhance students' SES, specifically emotional knowledge, social awareness, and relationship skills. Findings prove that structuring tech-supported cooperative learning programs can significantly enhance students' emotional and social competencies. While the observed changes in SES scores were modest in absolute value, they were statistically significant and consistent with previous findings using similar interventions. These results, although relatively small, may reflect meaningful progress in young students' perceived social-emotional competencies, especially considering the short duration and complexity of real-world classroom settings. Our data aligns with a growing body of research emphasising the promising effects of peer-mediated learning in fostering socioemotional development (Mercer & Howe, 2012). Moreover, the present results show that structured cooperative learning can effectively promote SES in fourth to sixth-grade students, extending previous evidence to primary and middle school contexts. Indeed, much of the existing research had primarily focused on adolescent populations, often emphasising remediation rather than early intervention; here, we reinforce the importance of early social-emotional development as a preventive measure. Research has shown that strengthening SES at a younger age enables children to develop essential emotional regulation and interpersonal skills before they reach adolescence, a period during which social challenges, emotional distress, and behavioural difficulties often become more pronounced (Jones et al., 2015; Wigelsworth et al., 2016). Moreover, these findings extended prior research conducted in the United States by Van Ryzin and Roseth (2019a, 2019b), Van Ryzin et al. (2020), which demonstrated that cooperative learning integrated with SEL principles can enhance students' social-emotional competencies and peer relationships in high school settings. By replicating and expanding these effects in primary and middle school students within the Italian educational context, our study provides further evidence of the cross-cultural applicability of structured, technology-supported cooperative learning interventions in fostering socio-emotional development.

This is especially true because the PeerLearning.net software has not been modified; it has only been translated into Italian. Therefore, its structure seems to be valid in different cultural contexts as well. Indeed, the fact that cooperative structures worked effectively in an Italian sample suggests that the benefits of CL may be broadly applicable across different cultural and educational settings, albeit with possible adaptations based on local norms and classroom dynamics (Buchs et al., 2017). Finally, another strength of this study was its ability to demonstrate significant effects despite the inherent variability across classrooms, teaching styles, and student differences. In real-world educational settings, variations in how teachers implement interventions, classroom dynamics, and individual student characteristics can often introduce challenges that dilute the effectiveness of structured programmes. However, considering the nested structure of our data, our findings suggest that the cooperative learning framework consistently promoted SES development, even when adapted to different class environments and teaching approaches. This variability, rather than being a limitation, emerged as a strength, highlighting the robustness of the intervention across diverse educational contexts. Despite these differences, the observation of SES improvements underscores the flexibility and adaptability of CL-based interventions, making them a viable and scalable approach for promoting socioemotional development in heterogeneous school environments. This overall impact is reflected in all the dimensions of socioemotional skills assessed in our study, each exhibiting distinct improvement patterns. The improvement in emotional knowledge aligns with research indicating that emotionally rich, discussion-based environments encourage deeper cognitive and affective engagement, allowing students to internalise and apply emotional concepts more effectively (Denham et al., 2012). The structured nature of our intervention may have reinforced this effect by offering repeated opportunities for emotional expression and feedback, processes known to strengthen neural pathways associated with socio-emotional learning (Davidson & McEwen, 2012). Social awareness and relationship skills, which progress further, support the idea that structured cooperation, focusing on specific abilities (such as turn-taking, help-seeking, and conflict resolution), enhances interpersonal skills beyond what is typically achieved through traditional instruction

(Slavin, 2015). Indeed, structured cooperative learning fosters students' ability to recognise and interpret social cues, enhancing their capacity for empathy and perspective-taking. Activities such as group inquiry and the jigsaw method may have played a crucial role in this improvement, as they require students to actively consider others' viewpoints and collaboratively construct knowledge (Aronson & Patnoe, 2011; Wentzel & Ramani, 2016). Moreover, by working interdependently toward shared goals, students developed stronger communication skills and learned to manage social interactions constructively (Slavin, 2015). These cooperative experiences likely reinforced pro-social behaviours, creating a more inclusive and supportive classroom environment. A key factor contributing to the success of the intervention is likely the structured nature of the lessons facilitated by the PeerLearning.net platform. The platform allowed teachers to focus on actively fostering SES by automating logistical elements such as group formation, instructional material distribution, and group processing. Rather than passively waiting for SES to emerge organically, teachers were able to intentionally scaffold these competencies within students' Zones of Proximal Development (Vygotsky, 1978), ensuring that SES were consistently reinforced throughout collaborative activities. This aligns with research emphasising the importance of guided interaction and explicit instruction in promoting SES growth (Durlak et al., 2011; Zins et al., 2004). The ability to intervene in real-time, model appropriate social behaviours, and encourage self-reflection likely enhanced students' ability to internalise and apply these skills meaningfully (Rimm-Kaufman et al., 2014). Additionally, the structured support provided by the platform may have facilitated teachers' adoption of evidence-based socio-emotional practices, ensuring that SES development was not merely a byproduct of collaboration but a central and intentional component of the learning process (Jones et al., 2013; Oberle et al., 2016). Lastly, another important factor that may have contributed to the effectiveness of the intervention is the job shadowing approach implemented during the initial CL lessons. By providing teachers with direct support from researchers in the early stages of the program, this strategy likely facilitated the faithful implementation of CL principles. It ensured that SES instruction was seamlessly integrated into the lessons. As highlighted in the intervention design, teachers

gradually took on more autonomy as they became familiar with the PeerLearning.net platform and the structured socio-emotional training modules. This progressive transition may have increased their confidence in managing group dynamics, reinforcing key SES behaviours, and maintaining fidelity to the instructional framework. Given that teacher preparedness and implementation fidelity are critical factors in the success of CL interventions (Johnson & Johnson, 2009), the job shadowing approach has played a key role in optimising classroom delivery and maximising student engagement in SES skill development. These findings support the notion that SEL and cooperative learning are mutually reinforcing, providing a promising framework for promoting academic success and social-emotional growth.

6.5 Limitations and Further Research

While this study provides valuable insights into the effectiveness of technology-supported CL in enhancing SES among primary and middle school students, several limitations should be acknowledged. First, the experimental design, although robust, lacks complete randomization (schools joined the project voluntarily, while assignment to groups was random), which may introduce potential selection biases and limit the ability to infer causal relationships. Second, although efforts were made to standardise the intervention, variations in teacher implementation and classroom dynamics may have influenced the outcomes, despite PeerLearning.net's support for the delivery of CL with fidelity to best practices. At the same time, we recognise that this variability in implementation may also represent a key strength of the intervention. In many educational systems, professional autonomy is a valued and necessary aspect of teaching practice. Indeed, the ability of teachers to adapt and integrate the PeerLearning.net-supported intervention within their own pedagogical style and classroom dynamics may enhance the ecological validity and practical sustainability of the approach. Third, SES were assessed using self-reported measures, which, despite their established validity, are subject to social desirability bias and may not fully capture behavioural

changes. Future research should continue exploring the mechanisms underlying these effects, focusing on potential moderators such as classroom climate and student characteristics. Moreover, while the SES measure was adapted from a validated instrument (WCSD-SECA), the specific 11-item version used in this study, along with the decision to exclude one of the original subscales, limits the generalizability and comparability of the results. Future studies should further investigate the validity and reliability of this shortened scale, particularly in primary and middle school populations. Regarding SES improvement, although the statistical results were significant, the magnitude of change in SES scores was relatively small. Future research should assess whether such differences translate into observable behavioural changes or long-term developmental gains, possibly through teacher ratings or performance-based assessments. Additionally, the study was conducted in a specific cultural and educational context (Italian schools), which may limit the generalisability of the findings to different educational systems. Another important limitation is the absence of an active control group. While the waitlist control design allowed for a comparison between students who received the intervention and those who did not, a more informative design could have included a second control group that received a different intervention, such as CL without technology (although certainly the children were doing some form of unstructured cooperative activity in their teaching). This would have helped disentangle the specific contribution of technology to SES development. However, conducting research in real-world school settings presents significant challenges, and logistical constraints often make it difficult to implement the ideal study design. Lastly, the relatively short duration of the intervention does not allow for conclusions about the long-term sustainability of SES improvements. Future research should incorporate a fully randomised controlled trial (RCT), including behavioural measurements or teacher ratings, to complement self-reported measures and explore longitudinal effects, thereby assessing the durability of SES gains over time. Finally, while the job shadowing approach likely contributed to the effective implementation of cooperative learning and SES instruction, it also represents a potential limitation. The presence of researchers and psychologists during the initial CL lessons may have provided an additional layer of support not

typically available in standard school settings. As teachers gradually took full responsibility for the lessons, it remains unclear to what extent they would have been able to maintain the same level of fidelity and effectiveness without this initial co-teaching phase. Future studies should examine whether similar outcomes can be achieved when teachers implement CL and SES instruction independently, without external expert support.

6.6 Practical implications

This study provides valuable insights into the ecological validity of structured CL integrated with SES development. Unlike controlled laboratory experiments, field studies capture the complexity of real-world interactions, enabling us to understand better how these interventions function in authentic educational contexts and how they can be effectively implemented at scale. The present findings have important implications for educators and policymakers. First, they highlight the potential of cooperative learning frameworks as a viable and effective strategy to enhance students' socio-emotional competencies. Schools should consider embedding structured cooperative instructional methods to maximise student engagement and interpersonal learning. This underscores the need for professional development programs that equip teachers with the necessary skills to facilitate these instructional strategies effectively. Providing educators with training in cooperative methodologies integrated with SEL principles, as suggested by Van Ryzin and Roseth (2019b), could enhance the overall impact of such interventions. Moreover, it is essential to note that the Italian system is a fully inclusive one. Therefore, all children, including those with Special Educational Needs (SEN), participated in CL structured lessons, benefiting from this opportunity. Lastly, given the observed benefits of the job shadowing model, schools should consider implementing SES programs that involve co-teaching with external experts, at least in the initial phases. Collaborations between teachers and psychologists or SEL specialists could provide targeted guidance, ensuring educators feel confident integrating SES instruction within cooperative learning settings.

6.7 Conclusions

These findings offer encouraging, albeit preliminary, evidence that structured, technology-supported cooperative learning can foster students' social and emotional development (emotional knowledge, social awareness, and relationship skills) among primary and middle school students. Significantly, the results extend previous research by showing that such interventions, when supported by digital tools, can be feasibly adapted for use with younger students and across different cultural contexts. The relatively successful use of the PeerLearning.net platform in Italian schools, with minimal adaptation beyond translation, underscores the potential scalability and cross-cultural relevance of this approach. Moreover, the study highlights the practical value of structured scaffolding and teacher support, both through technology and initial job shadowing, in ensuring high implementation fidelity and maximising the impact of the intervention. In sum, these results support the integration of tech-assisted CL into regular school curricula as a proactive strategy to build essential life skills from an early age. Future research should build on this foundation by examining long-term outcomes, assessing behavioural and teacher-reported changes, and exploring the mechanisms that sustain SES development over time and across diverse educational contexts.

Endnotes

¹The Italian education system is structured as follows: primary school lasts five years and starts at age 6, followed by lower secondary school for three years (ages 11–14). Upper secondary school lasts five years (ages 14–19) and includes various tracks such as lyceums, technical institutes, and vocational schools. At the end of upper secondary education, students take the national exam to obtain their diploma and access higher education.

²To encourage replicability, access to materials is available upon request to the author.

³CL structures are explained in the official PeerLearning.net website at this link: <https://www.peerlearning.net/lessons>.

Chapter 7 | “Just Put Them in a Group?” Teaching Cooperation in Childhood: Behavioral Effects of a Structured, Tech-Supported Intervention

Zagni, B., Van Ryzin, M., Ianes, D., & Scrimin, S. (submitted to the *British Journal of Educational Psychology*).

“Just Put Them in a Group?” Teaching Cooperation in Childhood: Behavioral Effects of a Structured, Tech-Supported Intervention

7.1 Theoretical Background

The previous study assessed SES through self-report measurement. As discussed in this dissertation, self-reports have several limitations, especially when you use them in schools. That is, the third study aimed at testing the effect of CL on a behaviorally measured cooperative task. It attempts to overcome the limitations of self-report measures and to reveal the positive outcomes of both CL intervention and behavioral measurement tasks. Indeed, cooperation is a fundamental aspect of human social life and a core component of prosocial behavior. It refers to the coordination of actions among individuals working toward a shared goal, in which mutual benefit is acknowledged and pursued (Bratman, 1992; Eisenberg & Miller, 1987). From a developmental standpoint, cooperative behavior begins to emerge early in life, with signs of joint attention and shared intentionality observable in infancy, typically between 0 and 3 years of age (Warneken & Tomasello, 2007, 2009). However, the ability to understand the value of cooperation, to engage in it strategically, and to sustain it across complex social interactions matures gradually throughout childhood (Grueneisen & Warneken, 2022). Especially during middle childhood, cooperation becomes more cognitively demanding and goal-oriented, as children acquire a deeper understanding of others’ perspectives, social norms, and long-term consequences of their actions (Gülseven et al., 2021; Laible et al., 2014). Overall, cooperation requires the ability to balance one’s own needs with those of others (Gülseven et al., 2023). As such, it lies at the core of functioning in any social environment, including the classroom. In everyday classroom life, cooperation may take the form of students jointly solving

a math problem, co-constructing a poster for a history project, or negotiating roles during a science experiment. Even routine activities, such as taking turns during discussions or organizing materials for a group task, require children to align their behavior with that of their peers, anticipate others' needs, and contribute toward a collective outcome. However, cooperation is not an automatic behavior, particularly in childhood. It involves a set of complex cognitive, emotional, and social skills that do not emerge spontaneously in group settings. Therefore, it is unrealistic to expect children to cooperate effectively merely by placing them together or assigning them shared goals. Instead, cooperation must be taught, promoted, organized, and practiced over time. Like any other developmental skill, it requires guided support, repeated opportunities for engagement, and a structured environment in which cooperative behaviors are modeled and reinforced (Gillies, 2016; Van Ryzin & Roseth, 2019; Zagni et al., under review).

Fostering Cooperation In Schools: Why and How To Do It

Classrooms are among the first structured environments where children are expected to collaborate toward shared goals, often with peers of varying backgrounds, abilities, and perspectives. As such, they are fertile ground for developing the social-emotional skills required to navigate increasingly complex interpersonal dynamics. When cooperative norms are explicitly valued and structurally embedded in classroom practices, students are more likely to adopt collaborative approaches as their default mode of engagement (Buchs et al., 2017; Gillies, 2014). It is desirable for a teacher to promote cooperation in the classroom, given that cooperation enhances motivation and engagement by fostering a sense of belonging and shared purpose (Johnson & Johnson, 2009) and contributing to a more positive and inclusive learning environment. Furthermore, cooperative experiences in school also prepare students for participation in democratic societies, where collaboration, mutual respect, and collective problem-solving are essential (Battistich et al., 2004). Promoting cooperation in the classroom, therefore, not only benefits immediate academic and social outcomes but also lays the groundwork for active, prosocial citizenship.

However, a growing body of research has revealed that cooperative behaviors do not emerge spontaneously in group settings; rather, they must be explicitly scaffolded, modeled, and supported through structured pedagogies such as Cooperative Learning (CL) (Gillies, 2016; Van Ryzin & Roseth, 2019). This approach aligns with the principles of evidence-informed education, which emphasize the integration of the best available research evidence with professional expertise and contextual factors to inform instructional decisions (Dell’Anna, Bellacicco, & Ianes, 2023; Vivanet, 2013). Within this framework, CL is not only a pedagogical choice but also an evidence-based strategy that has been shown to effectively promote prosocial development and academic engagement when implemented with fidelity. Evidence from intervention studies consistently shows that students who participate in structured cooperative learning experiences are more likely to engage in prosocial behaviors and develop cooperation skills (Johnson & Johnson, 2009; Buchs et al., 2017; Van Ryzin, Roseth, & Biglan, 2020). This is especially true when cooperative activities are designed with clear roles, mutual goals, and mechanisms for feedback. Importantly, the success of these approaches hinges on fidelity of implementation of CL: merely placing students in groups without structured interaction tends to reinforce individualism or passive participation (Gillies, 2004). Indeed, unstructured group work can lead to social loafing, dominance by a few members, or even interpersonal conflict (Buchs et al., 2017; Gillies & Boyle, 2010).

Key Design Principles for Effective Cooperative Learning

Cooperation must be intentionally cultivated through evidence-based design principles. Decades of research, most notably by Johnson and Johnson (2009), have identified core elements essential to effective CL: positive interdependence, individual accountability, explicit teaching of social skills, and group processing.

These structural components are critical to transforming group work into a cooperative experience. For example, positive interdependence ensures that students perceive their success as linked to that of their peers, encouraging mutual support and joint responsibility. Individual

accountability guarantees that each student remains engaged and contributes meaningfully to the group's task. Group processing helps students reflect on both their academic performance and the quality of their collaboration (Johnson & Johnson, 2013; Zagni & Van Ryzin, 2024). Explicit teaching of social skills supports students' development of key interpersonal competencies, such as active listening, turn-taking, or help seeking, since CL structures offer authentic, recurring opportunities to practice and refine these abilities within meaningful peer interactions (Zagni et al., under review).

There is a great deal of research supporting the hypothesis that these design elements are critical to supporting the development of cooperative behaviors. For example, a study by Gillies (2004) found that students engaged in CL activities exhibited increased helping behaviors and more positive peer interactions compared to those in traditional learning settings. Similarly, Johnson and Johnson (2009) reported that CL not only improves academic achievement but also promotes interpersonal skills and mutual support among students. A meta-analysis by Roseth et al. (2008) emphasized that the effects of CL are attenuated when fidelity of implementation is lower. These findings underscore the importance of implementing high-fidelity CL strategies to cultivate cooperative behaviors in educational environments.

More recent studies continue to support these findings. For example, a study by Gillies (2016) found that CL strategies lead to improved student engagement and cooperation. Additionally, Van Ryzin and Roseth (2019) conducted a cluster-randomized trial involving 15 middle schools and found that CL not only reduced bullying but also increased peer-relatedness and empathy, suggesting that structured group activities can foster a more prosocial, inclusive, and supportive classroom environment. Furthermore, research by Buchs et al. (2017) highlights that the success of CL depends on the fidelity of implementation, emphasizing the need for clear roles, mutual goals, and structured interactions. Their findings indicate that when CL is implemented with attention to these elements, students are more likely to engage in meaningful collaboration and develop essential social skills.

Although CL is widely supported by empirical research as a strategy to foster cooperation among students, its implementation in authentic classroom contexts often falls short of theoretical models.

Teachers frequently encounter difficulties in managing group dynamics, ensuring balanced participation, and maintaining adherence to the core principles of CL (Buchs et al., 2017; Gillies & Boyle, 2010). Without these foundational elements, cooperative behaviors may not emerge, and group work risks becoming either superficial or counterproductive (Abrami et al., 2004; Roseth et al., 2008). To overcome these challenges and support the development of authentic cooperation, the platform PeerLearning.net[©] was designed to assist teachers in structuring and delivering CL activities with high fidelity to key design principles. The platform automates key processes, including group formation, task and role distribution, and the facilitation of reflection phases, ensuring that cooperative structures are consistently and effectively applied across different lesson structures (Low & Van Ryzin, 2024; Zagni & Van Ryzin, 2024). By embedding key design principles into each lesson, PeerLearning.net fosters the kind of mutual engagement necessary for genuine collaboration.

Crucially, the system provides scaffolding not only for students but also for teachers, who are guided through the lesson flow and supported in monitoring group interactions. This reduces the cognitive and logistical burden typically associated with leading cooperative activities, allowing teachers to focus on facilitating meaningful peer interaction. The platform also includes features for group goal setting and processing, helping students reflect on how well they collaborated and how they can improve, an essential component in the development of long-term cooperative dispositions (Johnson et al., 2013).

7.2 The Present Study

Despite the strong theoretical and empirical foundation supporting CL, especially when implemented with fidelity, there is still a notable lack of research examining its behavioral impact on students' cooperative actions in real classroom settings. Most existing studies rely on teachers' ratings, self-report measures, or focus on broad social-emotional outcomes (e.g., peer-relatedness, empathy, reduced conflict), leaving open the question of whether structured CL interventions directly

foster observable, task-based cooperation, particularly in middle childhood, a critical developmental period for social skill acquisition. Indeed, a previous study by Zagni et al. (under review), also conducted on the same age range, found that tech-supported CL enhanced students' social-emotional skills; however, the outcomes were measured through self-report questionnaires, which may be subject to bias or social desirability effects. Given the interactive and relational nature of cooperation, there is value in complementing subjective measures with objective behavioral indicators (see, for example, Ianes et al., under review). To the best of our knowledge, there is a lack of research specifically examining the impact of technology-supported Cooperative Learning on observable cooperative behaviors, particularly among children in this developmental stage.

Thus, the present study aimed to investigate whether the use of PeerLearning.net can foster the development of cooperative behaviors in students, using a behavioral assessment rather than relying solely on self-report data. Specifically, the present study evaluates whether a tech-supported, fidelity-focused CL intervention can promote measurable changes in children's cooperative behavior using objective, game-based assessments.

7.3 Materials and Method

7.3.1 Study Design and Procedure

The study was conducted across multiple schools (primary and middle) in northeastern Italy. A total of 36 classes were randomly assigned to one of two conditions: 18 to the intervention group (Group 1) and 18 to the control group (Group 2). Schools were enrolled voluntarily. The control group received no intervention during the study period. Still, it was offered the opportunity to participate in the program during the following academic year, serving as a wait-list control.

The intervention began with two preparatory training sessions for teachers, held during the summer before the start of the school year. These sessions, facilitated by the lead researcher (a psychologist) and a trained research assistant, focused on cooperative learning, social and emotional learning, and

the use of the PeerLearning.net digital platform (see Figure 8 for an overview of the intervention timeline). Following the initial training, teachers received remote support through reading materials and instructional video content to help them prepare for classroom implementation.

Once the school year commenced, students in the intervention group participated in an initial set of four psychologist-led classroom sessions (Module 0, October–November), designed to develop socio-emotional competencies, including specific cooperative behaviors. These were followed by 16 cooperative learning lessons, integrated into regular reading comprehension instruction, delivered by Italian language teachers using PeerLearning.net software from November to May. During the first session, the research team supported teachers through job shadowing to ensure fidelity, after which teachers progressively assumed full responsibility for delivering the program. Support teachers² were also involved, where available.

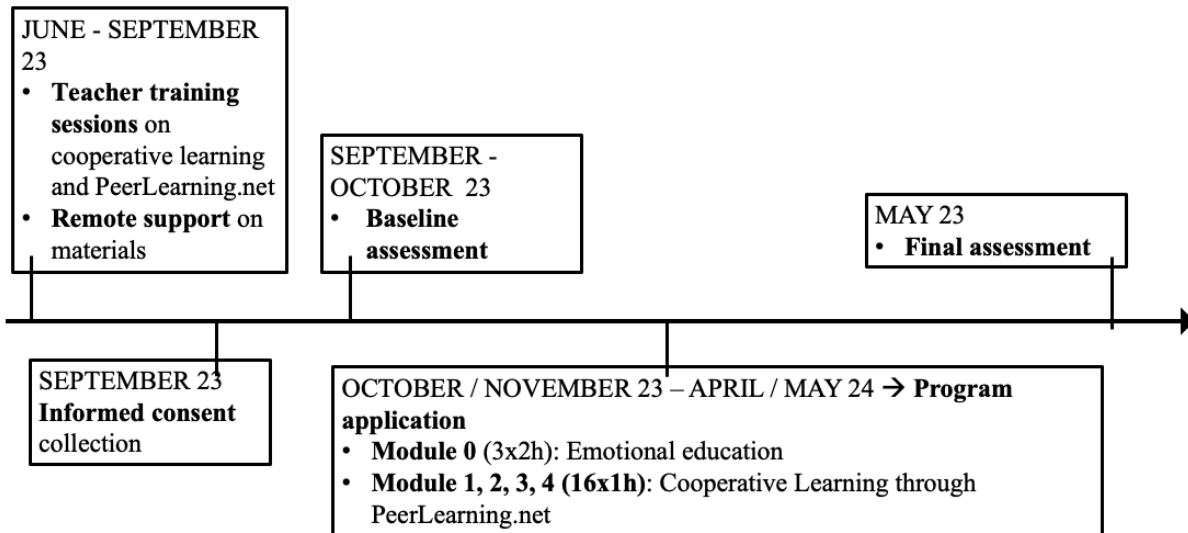
Data were collected at two time points (beginning and end of the school year) for both groups. The research protocol received approval from the relevant ethics committee (approval code: 96-a), and written informed consent was obtained from parents.

The administration of the cooperative game (see Measures section for details) took place in the classroom with all students present. The experimenter introduced the activity by informing the children that they would now play a partner-based game, each using their own tablet. The goal of the game was described simply as trying to win as many marbles as possible, with a maximum of 10 marbles available across 10 trials. No further instructions were provided to avoid priming the children toward cooperation or competition; this allowed them to independently discover that cooperation was the only effective strategy to obtain marbles. After the instructions, each student sat next to their assigned partner so they could interact freely during the game, including verbal exchanges if needed to coordinate their actions. This setup aimed to create a naturalistic context in which social behavior

² In the Italian school system, *support teachers* (*insegnanti di sostegno*) are assigned to classrooms where students with certified disabilities are enrolled. Their role is to promote inclusion by providing individualized support tailored to the specific educational and social-emotional needs of these students. Support teachers collaborate with subject teachers to adapt instruction and facilitate the full participation of all students in classroom activities.

could emerge spontaneously. At the end of the session, a brief debriefing was conducted to address any questions.

Figure 8 – Timeline Of The Intervention



7.3.2 Participants

A total of 607 students were initially recruited for the study, comprising 324 in the experimental condition and 283 in the control condition at Time 1 (pre-test). By the time of the post-test (Time 2), 314 students remained in the experimental group and 274 in the control group. To maintain data integrity and enable longitudinal comparison, only students who participated at both time points were retained for the final analyses. Indeed, students were excluded due to absence during one of the assessment sessions or school transfer during the academic year. This resulted in a sample of 577 students: 307 in Group 1 ($M_{age} = 9.48$, $SD = 0.79$) and 270 in Group 2 ($M_{age} = 9.63$, $SD = 0.79$). The sample included an even distribution across educational levels, comprising eight fourth-grade classes, eight fifth-grade classes, and two first-year middle school classes in each group.

CL Intervention and Cooperative Behaviors

To foster cooperative behavior, each lesson in the intervention was structured using one of three evidence-based Cooperative Learning formats (group inquiry, group project, and jigsaw), each of which incorporated all key design principles. These methodologies were selected for their effectiveness in promoting peer interaction, interdependence, and collaborative engagement (Van Ryzin & Roseth, 2018). Regardless of the specific socio-emotional skill targeted in each module – whether active listening, turn-taking, help seeking/giving, or conflict resolution – cooperation was a constant requirement embedded in the design of the learning environment.

All three CL structures emphasize positive interdependence and individual accountability, which are widely recognized as the foundational mechanisms of cooperation (Buchs et al., 2017; Johnson & Johnson, 2009). In group projects, students depended on one another to complete distinct but complementary components of a shared task (task-based interdependence). In group inquiry, each child assumed a specific role that contributed to the group’s problem-solving process (role-based interdependence). In the jigsaw format, each student was responsible for mastering and then teaching a portion of the content to their peers, reinforcing mutual reliance and equal participation. In all formats, the successful completion of the task depended on the active contribution of every group member.

This structure helped students understand, through direct experience, that achieving the lesson’s objective required cooperation: not simply working side by side but actively supporting one another to reach a shared goal. Rather than being an abstract ideal, cooperation became a necessity embedded in the task’s logic: *“I can only succeed if you do too.”* This aligns with theoretical perspectives that define cooperation as coordinated action toward mutual benefit (Bratman, 1992; Gülseven et al., 2023).

Ultimately, teachers (supported by the researchers, in a job-shadowing way) played a crucial role in fostering the development of these cooperative competencies. Within the framework of Vygotsky’s Zone of Proximal Development (Vygotsky, 1978), they acted as active scaffolds,

explicitly modeling cooperative behaviors, reinforcing them when observed, and providing formative feedback when group dynamics faltered. Drawing on the principles of Positive Behavior Support (Sugai & Horner, 2009), as promoted by PearLearning.net, teachers highlighted and rewarded verbal and nonverbal acts of cooperation, such as offering help, coordinating timing, or facilitating group reflection. By making cooperation both visible and valued, and by reinforcing it systematically, the intervention allowed students to develop cooperative behaviors not just as incidental outcomes, but as explicit, teachable skills (Gillies, 2016).

7.3.3 Measure

Cooperative behavior: the Marble Pull Game³

To assess cooperative behavior, we implemented a digital version of the Marble Pull game (see Figure 9), initially developed by Madsen (1971) to examine cooperation and competition among children. In the traditional version of the task, two children are seated opposite each other at a table, with a marble placed in the center. Each child holds a lever connected to a tray supporting the marble. To successfully retrieve the marble, both participants must coordinate their pulling action. If one child attempts to pull unilaterally or too quickly, the imbalance causes the marble to fall into a central hole, resulting in a loss for both players. Thus, the task inherently requires cooperation and turn-taking for success (Madsen, 1971; Madsen & Shapira, 1970; see also Kagan & Madsen, 1971).

We translated this paradigm into a tablet-based two-player game developed using the Unity game engine (Unity Technologies, 2023). Each child interacted with the game individually on their tablet, connected wirelessly to ensure real-time synchronization. In the digital adaptation, a marble appeared between the players on the shared virtual interface. Both players had to press and hold a button on their screens simultaneously and for a sustained duration to retrieve the marble and allocate it successfully. If one player acted too soon, too late, or released the button prematurely, the marble

³ A video of the game is available on: https://drive.google.com/file/d/1-zGnqvctcNc7dlnJpYpx16ncY1a3F_C5/view?usp=sharing

was lost. This mechanism preserved the original contingency of coordinated timing and cooperative intent. Before the main task began, a brief practice trial was conducted to ensure participants understood the mechanics of the game. During the experimental phase, each pair of participants had the opportunity to retrieve up to ten marbles. The number of marbles successfully collected was used as a quantitative index of cooperative behavior, with a maximum possible score of 10 per dyad. Each child's score ranged from 0 to 10, reflecting the number of marbles successfully obtained. However, this raw score did not fully capture the quality of cooperation in each dyad. Specifically, it did not distinguish between perfectly balanced collaborations (e.g., 5–5) and highly asymmetric outcomes (e.g., 9–1), despite both resulting in the same total score.

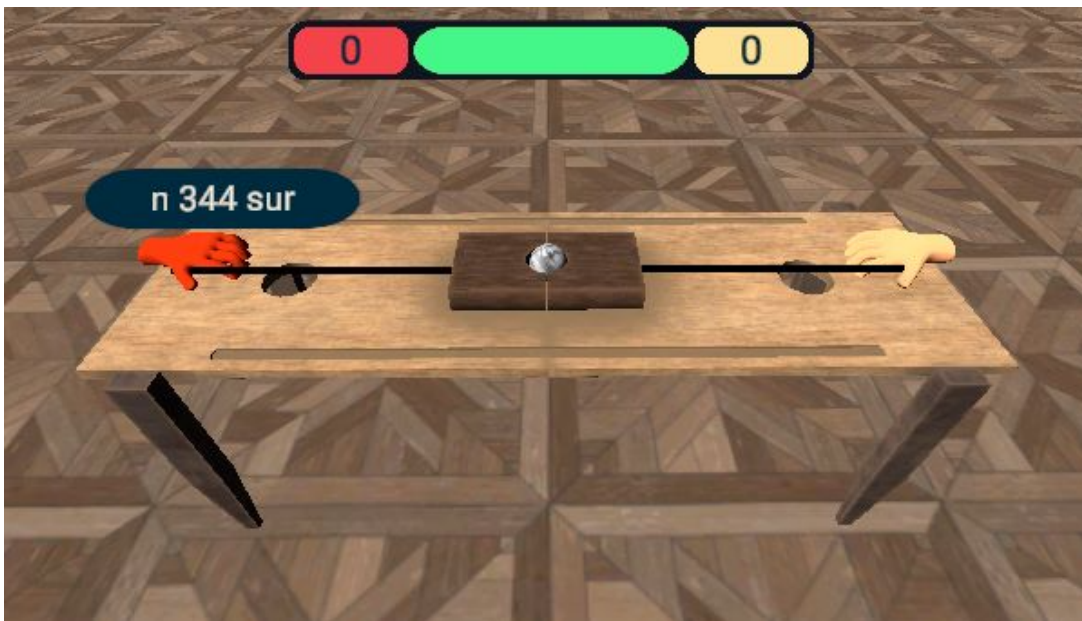
To address this limitation, we computed a normalized cooperation index that integrated both the amount of shared success and the degree of balance between the two participants. The index prioritizes outcomes in which both players receive a substantial and similar number of marbles, while penalizing unequal distributions. The computation is based on the lower of the two individual scores (*min*) and subtracts a scaled penalty determined by the absolute difference between the two scores.

The formula used is:

$$index = \frac{(min - \frac{difference}{2 \cdot (5 - min) + 1}) + 1}{6}$$

This approach ensures that cooperative outcomes are evaluated on a continuous scale from 0 (no cooperation: 0–10 or 10–0) to 1 (perfect cooperation: 5–5), with intermediate outcomes (e.g., 3–3 or 4–5) mapped accordingly. The resulting index provides a more sensitive and theoretically grounded measure of cooperative quality, taking into account both mutual benefit and equity.

Figure 9 – The Marble Pull Game



7.4 Results

All statistical analyses were conducted in R (Version 2025.05.0+496) using the packages lme4, mitml, broom, and performance.

Prior to conducting inferential analyses, we examined the distribution of the cooperation index to assess its overall shape and potential differences across groups and time points. Histograms revealed a positively skewed distribution, with most dyads showing low to moderate levels of cooperation at baseline, and visible shifts in distribution across sessions and groups (see Figures 10 and 11).

To investigate the effects of time, experimental group, and their interaction on cooperative behavior, we conducted a linear mixed-effects model on the normalized cooperation index. The model included fixed effects for time (Time 1 vs. Time 2), group (Group 1 vs. Group 2), their interaction, and age (centered categorical covariate with levels 9, 10, and 11). Random intercepts were included for class and participant ID. The model was estimated using restricted maximum likelihood (REML) on multiply imputed data (5 datasets), and pooled estimates were computed using Rubin's rules (Rubin, 1987).

Figure 10 – Global Distribution of Cooperation Index

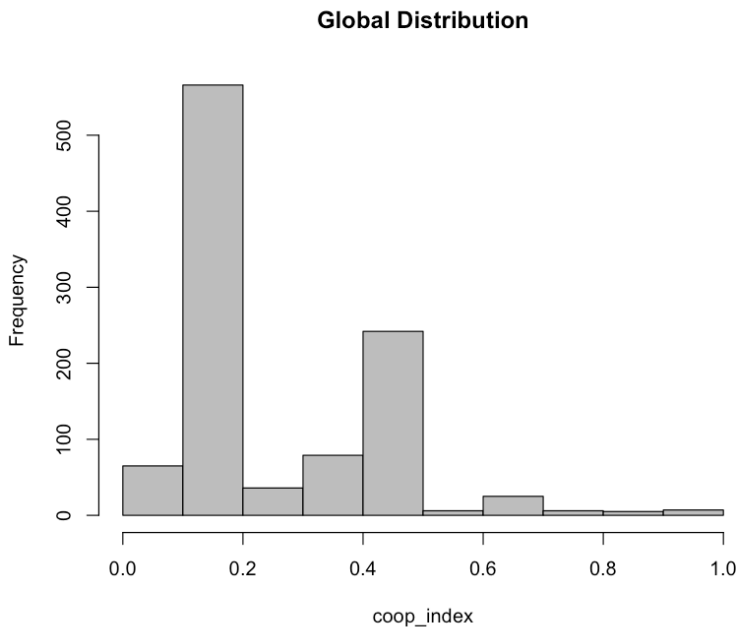
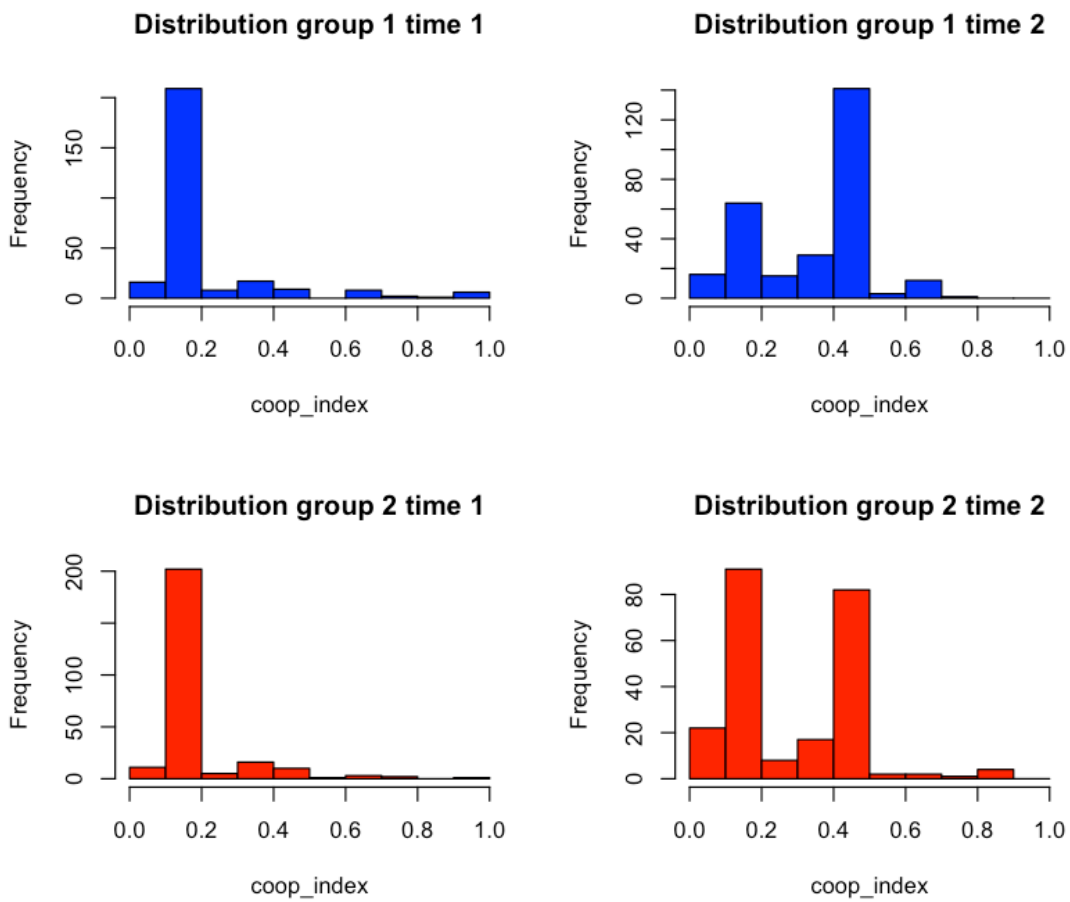


Figure 11 - Group-by-time Distribution of the Cooperation Index



The fixed effects results are reported in Table 7. A significant main effect of time was found, indicating higher cooperation at Time 2 compared to Time 1 ($\beta = 0.178$, $SE = 0.015$, $p < .001$). The main effect of group was not significant ($\beta = -0.019$, $SE = 0.022$, $p = .384$), nor were age effects. Crucially, the interaction between time and group was significant ($\beta = -0.067$, $SE = 0.024$, $p = .006$), indicating that the increase in cooperation over time was more minor in Group 2 compared to Group 1 (see Figure 12).

Model comparison using the D3 method (based on multiply imputed data) revealed that the full model explained significantly more variance than the null model, $F(6, 875.21) = 27.58$, $p < .001$. The pooled marginal R^2 (fixed effects only) was 0.153, and the conditional R^2 (fixed + random effects) was 0.247, indicating that both fixed and random effects contributed meaningfully to the explained variance.

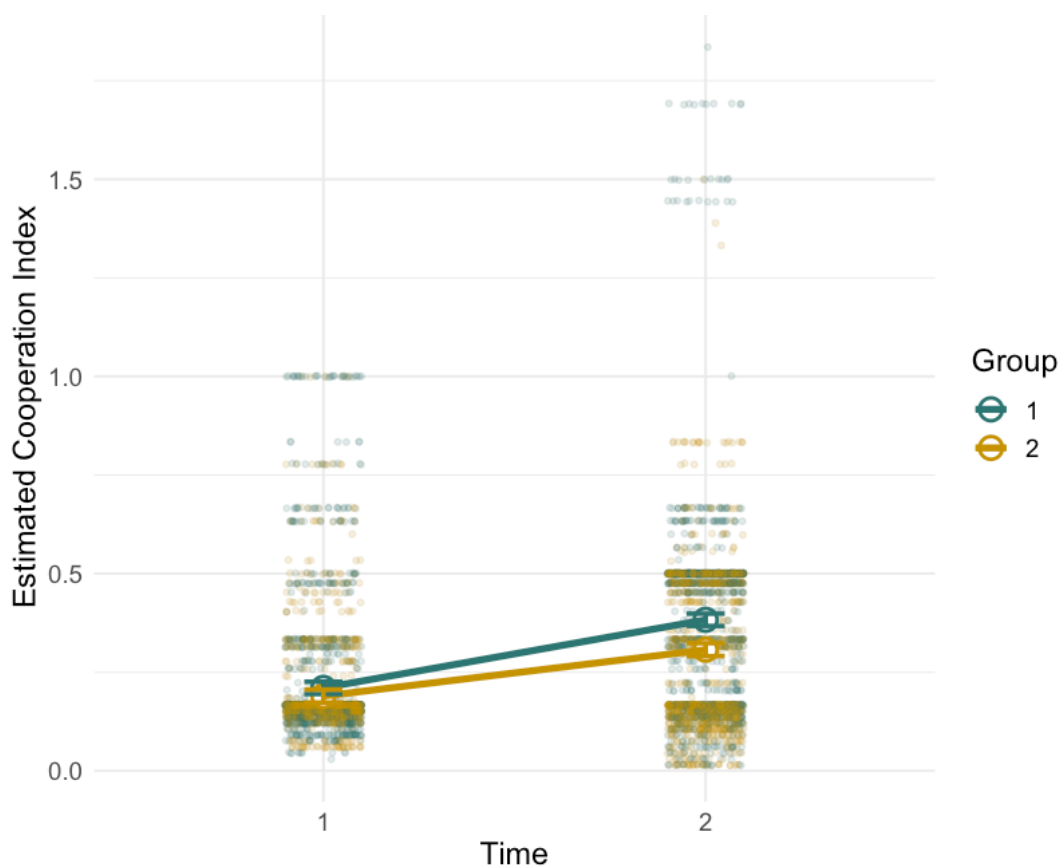
To further unpack the interaction between time and group, we conducted follow-up analyses to examine simple effects. Estimated marginal means revealed that both groups improved their cooperation scores from Time 1 to Time 2, but the magnitude of this improvement differed notably. In the intervention group (Group 1), cooperation increased from 0.210 to 0.383 ($\Delta = 0.173$), whereas in the control group (Group 2), the increase was from 0.190 to 0.307 ($\Delta = 0.117$). Additionally, we compared the two groups at each time point. At baseline (Time 1), no significant difference was observed between the groups ($p = .375$), indicating similar starting levels of cooperation. However, at post-test (Time 2), the difference between groups became significant ($p < .001$), with the intervention group showing substantially higher cooperation scores.

Table 7 – Effects of Time and Group on Cooperation Index

<i>Predictor</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>t-value</i>	<i>df</i>	<i>p-value</i>
Intercept	0.199	0.025	7.90	839.78	< .001 ***
Time (T2 vs T1)	0.178	0.015	11.87	256.97	< .001 ***
Group (G2 vs G1)	-0.019	0.022	-0.87	1103.33	.384
Age 9	0.0062	0.022	0.28	1033.62	.778
Age 10	0.0182	0.024	0.75	1058.10	.455
Age 11	0.0119	0.034	0.35	486.17	.723
Time × Group	-0.067	0.024	-2.81	66.99	.006 **

Note: $p < .05 = **$, $p < .001 = ***$

Figure 12 – Interaction Between Time and Group on Cooperation Index



Note: Group 1: intervention group, Group 2: control group

7.5 Discussion

The present study investigated whether a structured, technology-supported Cooperative Learning intervention could foster observable cooperative behaviors among elementary and lower-secondary students. Using a behavioral measure, the digital Marble Pull game, we assessed cooperation as an interactive and contingent skill, capturing not only the quantity but also the quality of mutual engagement. Our results showed a significant increase in cooperative behaviors over time, particularly in the intervention group, suggesting that structured CL, when implemented with fidelity, can effectively foster the development of cooperative skills. It should be noted that cooperative behavior increased across the school year, regardless of group assignment. This finding, in line with the existing literature, suggested a general developmental trajectory whereby students' ability to engage in mutual coordination improves with age and experience (Grueneisen & Warneken, 2022; Gülseven et al., 2021). In parallel, this may partially reflect a familiarity effect: students may have become more comfortable with the structure and contingencies of the Marble Pull game during the second session, leading to improved coordination independent of intervention exposure. In this context, the time effect provides a necessary baseline. If all students improved with repeated exposure, it becomes critical to examine whether the *rate* or *quality* of that improvement differs between conditions. Thus, the interaction between time and group further clarified and explained the effects in a broader sense. Indeed, it indicated that students in the experimental condition, who engaged in structured cooperative learning through PeerLearning.net, showed greater improvement in cooperative behavior compared to their peers in the control group. This finding provided behavioral evidence that cooperation is not a spontaneous by-product of group work (which was surely practiced weekly in the control group classes as it is usually in Italian primary schools), but rather a teachable social skill that can be systematically developed through intentional, structured teaching methods.

On one hand, the intervention's success can be attributed to the consistent application of key evidence-based principles, which are embedded directly into the structure of each lesson.

PeerLearning.net supported fidelity to these principles by guiding teachers in designing and managing group work that demands mutual coordination and shared responsibility. These results reinforced prior theoretical claims (Johnson & Johnson, 2009; Gillies, 2016; Van Ryzin & Roseth, 2018, 2019) and offered support for the view that structured, high-fidelity cooperative learning environments actively cultivate prosocial collaboration in primary and middle schools.

On the other hand, the intervention's effectiveness can also be attributed to the practical value of evidence-informed instructional models, particularly when paired with targeted, situated teacher support. In this study, one such support was the inclusion of expert-led job shadowing, in which an experienced educator worked alongside classroom teachers to model and co-facilitate structured cooperative lessons. This approach likely contributed to maintaining high implementation fidelity, a critical but often neglected factor in real-world educational interventions (Buchs et al., 2017). By observing, reflecting, and gradually taking ownership of the CL routines, teachers were able to internalize not only the "what" but the "how" of cooperative learning practice.

Furthermore, one of the strengths of the study was that, unlike prior studies that rely mainly on self-reports (e.g., Zagni et al., 2025), this study employed an objective behavioral measure, addressing concerns about social desirability bias and providing a more nuanced assessment of cooperative quality. This methodological approach contributes not only to the cooperative learning literature but also to the broader field of educational psychology, where objective behavioral assessments of peer interaction are still relatively rare. By using a real-time interactive task, this study avoided common pitfalls of self-report or teacher-report measures, such as limited introspective accuracy or teacher-rated halo effects (Wentzel & Watkins, 2002). It also provided a dynamic, situated view of cooperation as it unfolds in interaction, aligning with recent calls for more ecologically valid assessments of social-emotional skills (Denham, 2015). The normalized cooperation index offered an additional methodological advancement, as it operationalizes not only success but also how success is achieved, with balanced, mutually contingent action resulting in a higher score. This allowed for a

more precise capture of what distinguishes mere task completion from genuine cooperative engagement.

Moreover, our findings reinforced the idea that cooperation is not an automatic outcome of group work, but rather a teachable skill, consistent with prior research (Gillies, 2016; Van Ryzin & Roseth, 2019). The intervention emphasized key CL principles - positive interdependence, individual accountability, social skill development, and group processing (Johnson & Johnson, 2009) - which likely contributed to the observed gains. By embedding cooperation into the task structure and roles, students experienced firsthand that collaboration was not optional but integral to success (Buchs et al., 2017). This supported the theoretical framing of cooperation as coordinated, mutually beneficial action (Bratman, 1992; Gülseven et al., 2023). In addition to that, the intervention was not delivered independently but was integrated into learning tasks and thus did not take away from instructional time (and likely contributed to improved learning outcomes).

Finally, consistent with Vygotsky's sociocultural theory and the notion of the Zone of Proximal Development (Vygotsky, 1978), the PeerLearning.net platform provided both teacher and student scaffolding. Teachers were guided in structuring CL lessons and reinforcing prosocial behavior, while students practiced cooperation within a clear framework of interdependence. This structured support likely minimized the common pitfalls of unstructured group work, such as social loafing, dominance, and conflict (Gillies & Boyle, 2010), and instead created conditions for authentic and balanced collaboration.

7.6 Limitations and Future Directions

Although this study is the first to investigate, from a behavioral measurement, the increase in cooperation through CL, various limitations should be acknowledged. First, the study employed a single behavioral task, the Marble Pull game, as the primary outcome measure. While this task captures coordinated, real-time collaboration and has firm theoretical grounding (Madsen, 1971), it

focuses on a specific type of dyadic cooperation. Broader assessments, such as open-ended group tasks or socially complex classroom interactions, would provide a more comprehensive view of cooperative competence.

Second, the study was geographically limited to schools in northeastern Italy. Although the sample was age-diverse, contextual variables such as school climate, teacher training, or cultural attitudes toward group work may have influenced results. Replication in different educational systems and cultural settings is needed to determine the generalizability of the findings.

Third, although the intervention spanned several months, we captured only short-term changes. The long-term developmental impact of structured CL remains an open question. Future longitudinal studies should assess whether cooperative behaviors persist, generalize to new contexts, or translate into broader social-emotional competencies.

Moreover, while the inclusion of job shadowing with an expert educator likely enhanced fidelity and supported effective implementation, representing a key strength of the intervention, it also poses a limitation in terms of scalability, as such intensive, personalized support may not always be feasible or replicable in typical school settings. Another limitation is the absence of active control groups that either implemented a different cooperative learning system or used group work without adhering to key CL principles. Including such comparisons would have allowed us to disentangle whether the observed benefits stem specifically from the PeerLearning.net platform, from the fidelity to cooperative learning design elements, or from structured group work more generally.

Finally, integrating multi-informant data could strengthen future evaluations. Combining behavioral tasks with teacher ratings, peer reports, or physiological markers of self-regulation (e.g., cardiac vagal tone) would enable a richer, multidimensional understanding of how cooperation develops and how it is best supported.

7.7 Conclusions

This study provides behavioral hints that structured, technology-supported Cooperative Learning has the potential to shape cooperative behavior in classroom settings. Our findings support the view that cooperation is not simply elicited through group work but cultivated through intentional design. PeerLearning.net offers a promising model for embedding cooperative structures into educational practice to develop cooperative skills. Future research will be essential to deepen our understanding of how to sustain and scale such interventions for long-term impact on social development.

Chapter 8 | Unraveling Teacher Stress: A Cumulative Model of Risks and Protective Factors in Italian Schools

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8.1 Theoretical background

In line with the bio-psycho-social model tested in this dissertation, proximal factors such as teachers' characteristics play a crucial role in relation to students' SES development. Specifically, according to the Prosocial Classroom Model (Jennings & Greenberg, 2009), teachers can promote students' SES if and only if they are socially and emotionally competent and, thus, if they feel well. This is why, in the fourth study, we assessed teachers' stress levels to evaluate Italian teachers' well-being as a first step of students' SES development.

Indeed, over recent years, growing attention has been given to teachers' well-being. Emerging evidence suggests that modern teaching environments, with their increasing classroom complexities and administrative demands, may contribute to significant stress (Day, 2017). Indeed, teacher well-being has become an increasingly critical issue within educational settings. Many studies showed its considerable direct and indirect impact on educators, students, classroom climate, and students' academic performance (Collie et al., 2012; Hascher & Waber, 2021). Teaching is widely recognized as one of the most stressful professions, with increasing demands related to classroom management, administrative work, and the requisite to address diverse student needs (Day & Gu, 2010; Pyhältö et al., 2021). Indeed, teachers are exposed to multiple inter-connected sources of stress that have been grouped into four categories (firstly theorized by Duggan, 1997): student-related factors (e.g., teaching unmotivated students, keeping students engaged in the lesson and managing classroom routines), organizational factors (e.g., time pressure, teaching programs, workload, and bureaucracy);

interpersonal relationships (e.g., interactions with colleagues, principal, and families); personal factors (e.g., self-efficacy and concerns on personal status). Teacher well-being is directly linked to student well-being and academic success, as emotionally healthy teachers are better equipped to create supportive learning environments, manage classroom dynamics effectively, and foster students' social-emotional development, all of which contribute to better academic outcomes (Hascher & Waber, 2021; Jennings & Greenberg, 2009). According to Jennings and Greenberg's (2009) *Prosocial Classroom* model, teacher well-being (and emotional intelligence too, see Mancini et al., 2022 for a recent study) should be promoted as it is essential to create and maintain a positive educational environment that can foster students' success and social-emotional development (Jennings & Greenberg, 2009; Jennings et al., 2017). Conversely, high stress levels can impair teachers' ability to manage classrooms effectively, diminishing instructional quality and weakening teacher-student relationships. This, in turn, has been linked to lower student engagement, emotional distress, and poorer academic achievement (Kyriacou, 2001; Cohen et al., 2007). Furthermore, teacher stress contributes to absenteeism, job dissatisfaction, and attrition, posing systemic challenges for education systems struggling with teacher retention (OECD, 2021a). Organization for Economic Cooperation and Development data indicate that across many countries, approximately 30% of teachers leave the profession within their first five years (OECD, 2021a). Teachers' stress, however, varies significantly across countries as a phenomenon influenced by systemic and cultural factors. Studies conducted in Northern Europe (Skaalvik & Skaalvik, 2017), North America (Montgomery & Rupp, 2005), and Asia (Hojo, 2021) have consistently highlighted the role of workload, bureaucracy, and student behavior as significant stressors. Furthermore, studies comparing teacher stress across different countries have revealed notable differences in policy-driven stressors, with high-stakes accountability policies in the United States and the UK leading to increased stress levels (Day & Gu, 2010). In contrast, Nordic countries emphasize teacher autonomy, which has been associated with lower stress levels (Hakanen et al., 2006). In Southern Europe, specifically in Italy, where research remains scarce,

stress has been linked to bureaucratic overload and limited career advancement opportunities (Garcia-Carmona et al., 2019; OECD, 2019).

Hence, considering the urgent issue of teacher stress and its far-reaching implications for educators and students and the need to explore a more comprehensive and context-specific understanding of its contributing factors, the present study aimed to investigate the cumulative perceived stress experienced by Italian teachers.

8.1.1 The Cumulative Model of Teachers' Stress

Various theoretical frameworks have been proposed to explain teacher stress, each offering distinct perspectives on its antecedents and consequences. Specifically, stress is a universal experience when individuals perceive a mismatch between their demands and coping ability (Lazarus & Folkman, 1984). Over time, accumulating stressors can lead to significant psychological and physiological consequences, emphasizing the importance of understanding the factors that influence individuals' stress perception (Cohen et al., 2007). Stress is not experienced uniformly; instead, it is a profoundly personal phenomenon shaped by an individual's unique circumstances, resources, and coping mechanisms (Shields & Slavich, 2017). This variability in stress experiences highlights the necessity of theoretical models that explain how job-related factors contribute to stress in different professional contexts

One of the most widely used models is the Job Demand-Resource (JD-R) Model (Bakker & Demerouti, 2007; Barbieri et al., 2019), which conceptualizes stress as an imbalance between job demands (e.g., workload, emotional exhaustion) and available resources (e.g., autonomy, social support). Another influential framework is Kyriacou's Model of Teacher Stress (Kyriacou, 2001), which is specifically designed to address stress within the teaching profession. Kyriacou defines teacher stress as a negative emotional response resulting from excessive work demands, role conflict, and lack of support, identifying five primary categories of stressors: classroom-related stressors,

workload and time pressure, role conflict and ambiguity, bureaucratic and institutional demands, and interpersonal relationships. While these models provide valuable insights into the nature of stress, they consider stressors in isolation rather than examining how multiple factors accumulate over time. In contrast, the Cumulative Stress Model (Mann et al., 2021) provides a comprehensive approach, recognizing that the negative effect of stress results from simultaneous and prolonged exposure to multiple stressors. Unlike models focusing on singular or short-term stressors, this approach highlights how prolonged exposure to various professional, administrative, and interpersonal demands can compound teachers' stress levels, increasing their vulnerability to burnout. This perspective is particularly relevant in educational settings, where teachers must navigate a persistent interplay of workload pressures, bureaucratic constraints, and social expectations that, over time, shape their overall stress perception. Indeed, cumulative perceived stress reflects the subjective evaluation of multiple stressors over time and their combined effect on an individual's well-being (Mann et al., 2021). This model also aligns with the broader conceptualization of stress proposed by Epel et al. (2018), which considers stress a cumulative and multidimensional process influenced by biological, psychological, and environmental factors.

8.1.2 Risk and Protective Factors

According to the Cumulative Stress Model (Mann et al., 2021), stress emerges from isolated stressors and their prolonged accumulation over time, as multiple demands interact and compound their effects. This accumulation is particularly relevant in the teaching profession, as educators face a constant interplay of professional, administrative, and interpersonal stressors that gradually threaten their well-being. Within this framework, stressors - often categorized as risk factors in the literature - play a central role in influencing perceived stress levels by imposing demands that exceed an individual's coping capacity (Schneiderman et al., 2005). Among the most frequently reported sources of stress is the heavy workload, which encompasses lesson planning, grading, administrative

responsibilities, and the challenge of addressing increasingly diverse student needs, often within tight time constraints (Kyriacou, 2001). Interestingly, a recent study conducted in Italy revealed the central role of teaching practices in teachers' well-being (Mameli & Molinari, 2017). The key findings revealed that regardless of school grade and teaching experience, interactive practices that encourage student participation were associated with lower burnout levels. In contrast, teacher-centered approaches and flexibility were linked to higher burnout. In Italy, the most critical source of distress reported is bureaucracy-related issues. Excessive administrative demands and rigid procedural requirements take away teaching time and create a sense of frustration and inefficiency, particularly within systems with limited support (Garcia-Carmona et al., 2019; OECD, 2019).

Additionally, poor relationships with colleagues or the school leadership and a lack of professional recognition have been reported to exacerbate stress further (Barbieri et al., 2019). When collegial relationships are characterized by conflict or lack of cooperation, teachers may feel isolated and unsupported, which can heighten feelings of burnout and emotional exhaustion (Wolgast & Fischer, 2017). Similarly, unsupportive or overly critical leadership may fail to provide the guidance and encouragement necessary for teachers to thrive, instead fostering a sense of frustration and undervaluation (Grayson & Alvarez, 2008). The lack of professional recognition, including acknowledgment of achievements or contributions to the school community, can significantly undermine teacher morale, reducing their sense of purpose and job satisfaction (Pearson & Moomaw, 2005). Likewise, interactions with students' families represent a substantial source of stress for teachers, as managing conflicting expectations, communication barriers, and the demands of ongoing collaboration often impose additional emotional and professional challenges (Grayson & Alvarez, 2008; Johnson et al., 2020).

Despite these challenges, numerous protective factors can mitigate the impact of cumulative perceived stress, buffering individuals against the demands posed by various stressors. Indeed, stress can be mitigated through different resources and strategies that enable coping with stress effectively (Lazarus & Folkman, 1984). Daniilidou and Platsidou (2022) showed how teachers' ability to adjust

to teaching challenges was linked to internal and external factors. The first includes personal traits like emotional intelligence (for a recent study, see Mancini et al., 2022), optimism, commitment to professional growth, and effective problem-solving and emotional regulation strategies. External factors encompassed supportive relationships within and outside the school environment, such as collaboration with colleagues, emotional support from family and friends, and awareness of educational laws. Several studies have identified positive social support from colleagues and school leadership as an essential protective factor (Bagdžiūnienė et al., 2022; Ferguson et al., 2017; Hascher & Waber, 2021). Teachers who feel supported by their colleagues and administrators report lower levels of stress and a greater sense of job satisfaction (Collie et al., 2012; Leithwood et al., 2008; Mancini et al., 2022). Professional collaboration, where teachers can share resources, strategies, and emotional support, creates a buffer against burnout by fostering a sense of community and shared purpose (Skaalvik & Skaalvik, 2017). Similarly, positive relationships with students' families and supportive principals can act as protective factors, enhancing teachers' well-being (Grayson & Alvarez, 2008).

Furthermore, access to psychological support within and outside the school setting can also serve as a protective factor to alleviate stress. The availability of school psychologists or counseling services allows teachers to effectively address emotional and professional challenges, reducing the risk of burnout (Richards et al., 2016). External therapy options provide additional support, helping teachers develop strategies to manage stress and enhance resilience (Montgomery & Rupp, 2005). Finally, engaging in hobbies and maintaining informal relationships, such as a strong social network outside of work, are critical protective factors for teachers' well-being. Hobbies can reduce stress by providing opportunities for emotional and mental disengagement from work (Hakanen et al., 2006). In the same way, positive social relationships outside the school context contribute to overall well-being and resilience (Hobfoll, 2001). Engaging in informal interactions with friends and family provides teachers emotional support, a sense of belonging, and opportunities to detach from work-related stressors. These relationships often serve as a vital outlet for expressing frustrations and

regaining perspective, reducing the risk of burnout and enhancing psychological recovery (Hakanen et al., 2006; Hobfoll, 2001). By maintaining strong connections outside the professional sphere, teachers can cultivate a balanced and fulfilling personal life, supporting their capacity to cope with workplace demands. Last, job satisfaction, particularly in intellectual stimulation and recognition areas, significantly influences teachers' capacity to cope with stress and maintain engagement (Hakanen et al., 2006).

Taken together, these results suggest that teachers' cumulative stress is shaped by a balance between multiple risk factors that exacerbate stress and protective factors that help mitigate its effects.

8.1.3 Aim of the Study

While extensive research has been conducted on teachers' sources of stress, previous studies mainly focused on single factors (Kyriacou, 2001; Montgomery & Rupp, 2005; Skaalvik & Skaalvik, 2011) instead of considering multiple factors combined simultaneously that contribute to cumulative perceived stress (Mann et al., 2021). This approach may limit a comprehensive understanding of the phenomenon, as it does not identify the most influential risks and protective factors of teacher stress or evaluate their collective contribution to explaining variations in stress perception. Moreover, while teacher stress has been widely explored in North America and Northern Europe, studies in Italy remain scarce, particularly in examining the cumulative nature of stress and the relevance of multiple risk and protective factors.

Thus, this study extends existing research by moving beyond single stressor approaches to examine the cumulative perceived stress experienced by teachers. Bearing in mind the multifaceted nature of teacher well-being, it aims to explore the risks and protective factors of cumulative perceived stress among Italian teachers through a comprehensive framework, examining the contribution of risk and protective factors while considering demographic characteristics and contextual school factors. Indeed, research suggests that years of teaching experience may moderate

stress levels, despite controversial findings (Mancini et al., 2022). Some studies revealed that newer teachers are more vulnerable to burnout due to a lack of coping strategies (Johnson et al., 2020; Klassen, 2010), while others reported older teachers as more emotionally exhausted (Mancini et al., 2022). Finally, contextual factors such as school socio-economic status (SES) and multicultural dynamics can amplify or mitigate stress, shaping teachers' perceptions of their work environment (Richards et al., 2012). Hence, the following research questions guided the study:

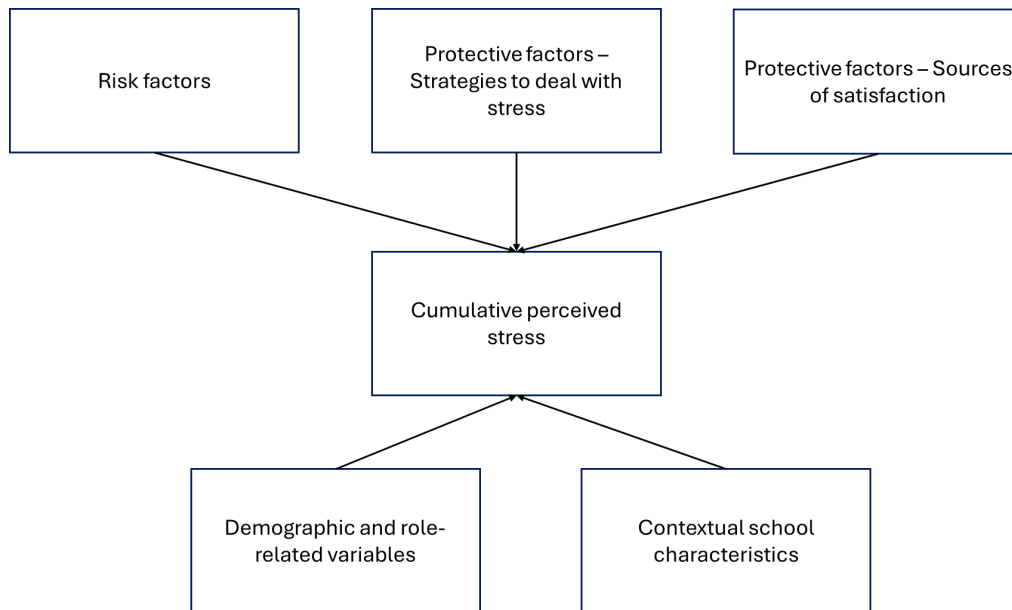
RQ1) What are the most common risk and protective factors teachers report?

RQ2) Could risk and protective factors be grouped into broad categories?

RQ3) To what extent do risk and protective factors independently predict variations in teachers' cumulative perceived stress, and how do these associations change when all factors are considered together alongside demographic characteristics (e.g., years of experience, contract type) and contextual school variables (e.g., socio-economic status, school type)?

The hypothesized model tested in our study is represented in Figure 13. This study extends the understanding of teacher-perceived stress and its underlying determinants by incorporating all these factors. Exploring which factors are the most relevant in explaining teachers' stress could offer practical insights to inform social policies. Addressing this research gap, especially in Italy, would help develop targeted interventions and support structures, enhancing teachers' professional experience and well-being.

Figure 13 – Theoretical model used in the study



8.2 Methodology

8.2.1 Participants

A sample of 1979 Italian teachers voluntarily participated in the study and completed all the questionnaires. Gender was included as an independent variable in the analyses. Therefore, participants who did not disclose their gender ($n = 23$) and those who identified as a gender other than man or woman ($n = 3$) were excluded. The latter group was excluded due to its small size, which did not allow meaningful comparisons with the other two groups. Data were screened for careless responders using the *careless* package (Nicholls, 2022). Long-string analysis was used to identify the long sequence of identical responses across all the administered questionnaires. Following this procedure, 49 participants were excluded.

The final sample consisted of 1904 teachers (78 men, 1826 women) with a mean age of 45.12 years ($SD = 8.82$). The higher prevalence of women in our sample aligns with the current gender

distribution of teachers in Italy. On average, they reported having worked in schools for 14.28 years (SD = 10.17). Table 8 provides sociodemographic and school-related information.

Table 8 – Descriptive Statistics of the Sample

Gender	
Men	78 (4.10%)
Women	1826 (95.90%)
School Grade	
Kindergarten	348 (18.28%)
Primary school	781 (41.02%)
Middle school	412 (21.64%)
High school	363 (19.07%)
Teaching contract	
Tenured teacher	402 (21.11%)
Temporary teacher	1502 (78.89%)
Teaching type	
Classroom teacher	1086 (57.04%)
Special education teacher	818 (42.96%)
School Context	
Urban	1207 (63.39%)
Suburban	446 (23.42%)
Rural	251 (13.18%)

School Socio-Economic Status (SES)	
Low	410 (21.53%)
Medium	1385 (72.74%)
High	109 (5.72%)
Multicultural School	
Yes	711 (37.34%)
Partly yes	819 (43.01%)
No	374 (19.64%)

We did not estimate the sample size in advance; instead, we aimed to reach the highest possible number of teachers within the limited data collection timeframe (see Data collection). Additionally, our sample size aligns with previous studies using similar methodologies (Collie et al., 2012; Skaalvik & Skaalvik, 2017; Woods et al., 2023).

8.2.2 Procedure

The present research deploys a cross-sectional correlational design (Goodwin, 2010). In this approach, participants complete questionnaires once, providing a snapshot of the variables of interest. To this end, a self-report survey was developed to collect data.

The Ethical Committee of the University of Padua approved the study prior to data collection. The survey was administered online via Qualtrics®. Data collection took place over one month between August and September 2023. In Italy, school activities are suspended during this period, and no lessons are scheduled. Conducting the study at this time allowed us to capture teachers' overall

perception of stress without the potential influence of situational factors, such as particularly demanding school year periods with a high concentration of meetings or lessons.

The questionnaire was distributed in collaboration with Centro Studi Erickson, which spread the survey through its social channels. This allowed us to have a national sample from all the Italian regions. Participants accessed the questionnaire through a link and were presented with the informed consent form before beginning. Since data were collected anonymously, researchers could not send reminders to participants who left some questions unanswered.

8.2.3 Measure

The survey is based on a questionnaire developed by Keith Herman's research group (e.g., Woods et al., 2023) at the University of Missouri. The scale was translated into Italian and adapted with additional sections tailored to the Italian context and specific research interests (see the complete survey in Table 9). The scale consists of three questionnaires: one focusing on risk factors (9 items) and two focusing on protective factors (strategies for coping with stress, eight items; sources of satisfaction, seven items). Given that this is the first study to use these questionnaires in the Italian context, we did not aggregate item scores into predefined scales. Instead, we conducted a Principal Component Analysis (PCA) to examine the underlying structure of the measures and extract component scores for use in subsequent analyses. More details on the PCA are provided in the Data Analysis section.

Additionally, teachers reported their cumulative perceived stress on a single item ("How stressful do you think being a teacher is?") on an 11-point Likert scale (from 0 = not at all stressful to 10 = extremely stressful).

Finally, the survey included questions addressing demographic information: gender, year of experience, teaching type and contract, school grade, school context, school SES, and the school's multiculturalism. Demographic characteristics are reported in Table 8.

Table 9 – Descriptive Statistics for All the Items Included in the Questionnaires

	<i>Mean</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Min.</i>	<i>Max.</i>
Cumulative perceived stress	8.04	1.64	-1.24	5.34	0	10
Risk factors						
On a personal level, what are the primary sources of stress you experience?						
1) Personal Life.	3.89	2.71	0.36	2.13	0	10
2) Relationship with colleagues.	5.24	2.88	-0.11	1.91	0	10
3) Relationship with the school principal.	4.36	3.08	0.26	1.86	0	10
4) Classroom management.	4.90	2.79	-0.08	1.97	0	10
5) Relationship with students' families.	5.61	2.88	-0.29	2.02	0	10
6) Students' needs and requirements.	5.04	2.84	-0.13	1.97	0	10
7) School bureaucracy.	7.36	2.65	-1.07	3.31	0	10
8) Educational and lesson planning.	4.91	2.87	-0.02	1.97	0	10
9) Carrying out an under-recognized and insufficiently paid profession.	7.16	2.99	-0.91	2.71	0	10
Protective factors - Strategies to deal with stress						

What are the main strategies you use to cope with work-related stress?

1) I talk about this with my colleagues.	6.39	2.56	-0.65	2.69	0	10
2) I talk about this with my family.	6.00	2.82	-0.48	2.25	0	10
3) I talk about this with my friends.	4.82	2.89	-0.04	1.88	0	10
4) I take some time for myself.	6.16	2.81	-0.51	2.22	0	10
5) I engage in activities that I enjoy.	6.42	2.79	-0.58	2.31	0	10
6) I seek advice from a colleague.	6.65	2.56	-0.77	2.86	0	10
7) I talk about this with the school psychologist.	2.32	2.92	1.25	3.32	0	10
8) I talk about this with my therapist.	2.44	3.40	1.20	2.85	0	10

Protective factors - Sources of satisfaction

What are the sources of satisfaction in your work?

1) Remuneration.	3.68	2.47	0.14	1.95	0	10
2) Career opportunities.	2.98	2.43	0.61	2.56	0	10
3) Social recognition of the role.	3.54	2.68	0.49	2.27	0	10

4) Satisfaction with the quality of the relationship with students.	8.55	1.66	-1.86	7.70	0	10
5) Intellectual stimulation (study, preparation of materials...)	7.98	1.95	-1.47	5.60	0	10
6) Satisfaction with students' learning.	8.55	1.55	-1.63	7.01	0	10
7) Satisfaction with colleague teamwork.	6.73	2.60	-0.79	2.89	0	10

8.2.4 Data analysis

All analyses were conducted using RStudio (Posit Team, 2024). To answer our first research question (RQ1), we examined the most common risk and protective factors reported by teachers and ranked them according to their prevalence. The mean and standard deviation of the items in each questionnaire were calculated to understand the overall distribution and variability of responses. We also examined the distribution of cumulative perceived stress ratings (single item).

A PCA was conducted separately for each of the three questionnaires on risk and protective factors to identify potential item overlaps and reduce the number of variables for subsequent regression analysis (RQ2). Since these questionnaires had not been previously used in the Italian context, PCA was employed as an alternative to aggregating items into predefined scales. We used the package *psych* (Revelle, 2024) to carry out the PCA. Three indices were used to check the test the assumptions required for the PCA (Field et al., 2012): Kaiser-Meyer-Olkin-Kriterium (values higher than .50 indicate that component analysis should yield distinct and reliable components), the Barlett's test of sphericity /a p-value < .05 suggests the presence of clusters of correlated variables), the determinant of the correlation matrix (values lower than .00001 identifies issues of multicollinearity or singularity). Three criteria were used to determine the number of components to extract from the

PCA: the scree test, the eigenvalue-greater-than-one criteria, and the interpretability of the solution (Bikos, 2023). An oblique rotation (oblimin) was used, which allows factors to be correlated. Communalities of each variable were examined to ensure the extracted components explained adequate variance. Finally, principal components were extracted to be used in subsequent analysis.

A correlation analysis (Pearson's r) examined bivariate associations among all extracted components and their relationships with cumulative perceived stress. We then tested which individual and contextual factors were significantly associated with teachers' cumulative perceived stress (RQ3). Since perceived stress was measured on an ordinal scale (0 to 11), we selected proportional-odds logistic regression with a logit link as it allows for ordered categorical dependent variables. A stepwise approach was used to develop five models, incrementally adding conceptually related blocks of predictors to assess their impact on perceived stress:

- Model 1 included demographic and role-related variables (gender, years of experience, teaching contract).
- Model 2 added contextual school characteristics (school grade, context, socio-economic status, and multiculturalism). Due to the limited number of teachers who reported their schools as having a high SES (5.72%), teachers who reported a high SES for their schools were combined with those who reported a medium SES for this analysis.
- Model 3 added the components extracted from the risk factors questionnaire using the PCA.
- Model 4 added the components extracted from the strategies to deal with the stress questionnaire using the PCA.
- Model 5 added the components extracted from the sources of satisfaction questionnaire using the PCA.

For interpretability, grade, multiculturalism, and school context were entered into the model as dummy variables. We fitted each model using the *polr()* function from the *MASS* package (Venables & Ripley, 2022), which supports cumulative link models for ordinal logistic regression. Model comparisons were conducted using likelihood ratio tests to evaluate whether each set of predictors

significantly improved model fit. Additionally, we examined Akaike Information Criterion (AIC) values for each model, with lower AIC values indicating better-fitting models. Finally, we used the best-fitting model to explore which variables were significantly associated with cumulative perceived stress. The Lipsitz goodness-of-fit test used the *generalhoslem* package (Jay, 2019) to assess the overall model fit. Coefficients were interpreted as odd ratios. After Bonferroni correction for multiple comparisons, we considered a statistical significance threshold of $p < .002$.

8.3 Results

8.3.1 Descriptive analysis

As a first descriptive analysis, we observed that most teachers reported high levels of cumulative perceived stress as assessed by the single item ($M = 8.04$; $SD = 1.64$; see Figure 14). Regarding risk factors, school bureaucracy and social recognition of the teacher's role were the most frequently reported (Figure 15). In terms of protective factors, most of the strategies for coping with stress received mean scores between 4.82 and 6.65, while seeking support from a school psychologist ($M = 2.32$) and a therapist ($M = 2.44$) received lower scores (Figure 16). Finally, the sources of satisfaction that received the highest scores from teachers were the relationship with students and the intellectual stimulation derived from teaching and supporting students' learning (Figure 17).

Figure 14 – Distribution of Cumulative Perceived Stress (single item) Across the Total Sample

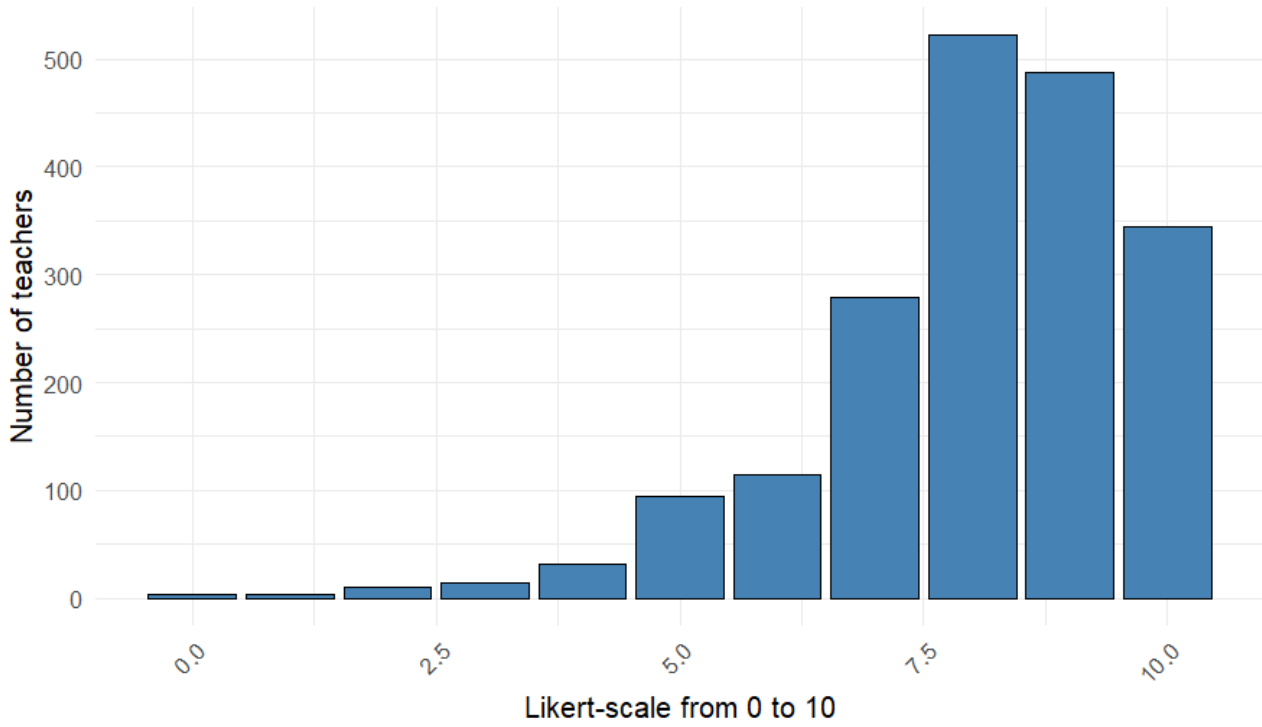
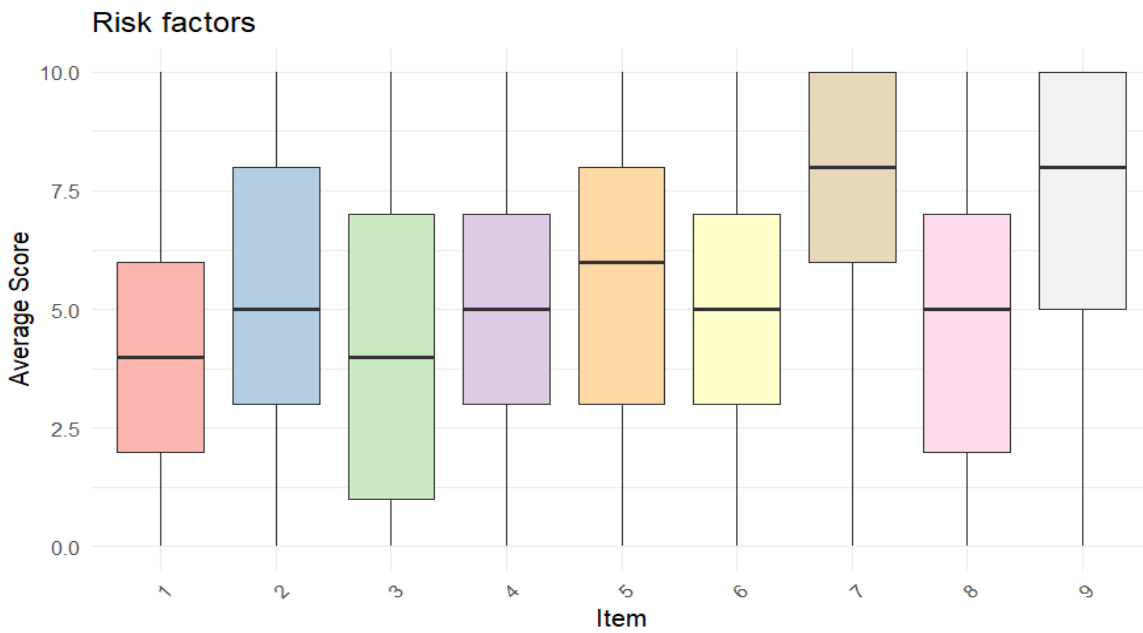
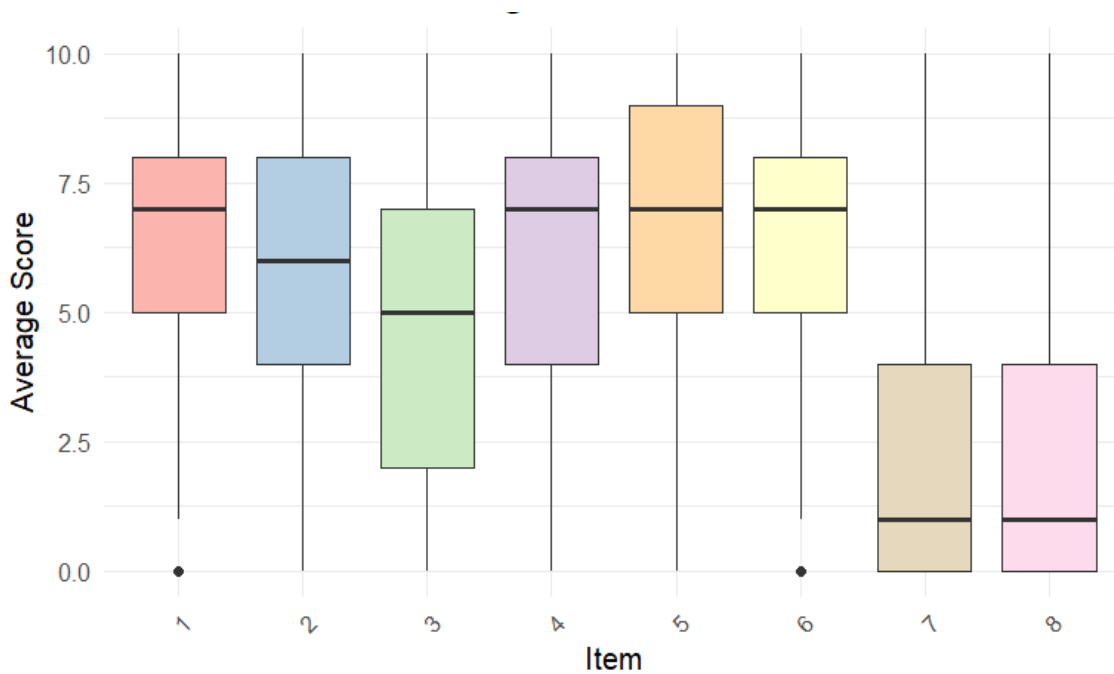


Figure 15 - Distribution of Risk Factors



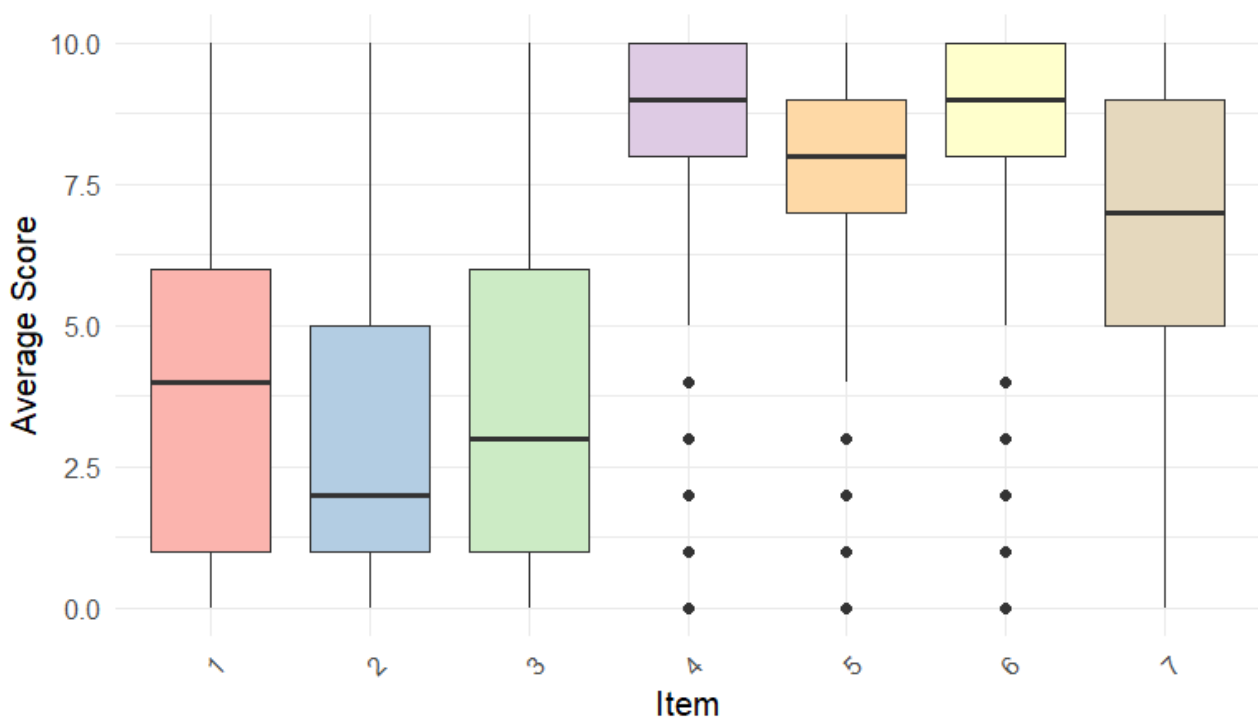
Note. 1 = Personal life; 2 = Colleagues; 3 = School principal; 4 = Classroom management; 5 = Students' families; 6 = Students' needs and requirements; 7 = School bureaucracy; 8 = Educational and lesson planning; 9 = Profession recognition.

Figure 16 – Distribution of the Strategies to Deal With Stress



Note. 1 = Talk with colleagues; 2 = Family; 3 = Friends; 4 = Personal time; 5 = Personal activities; 6 = Advice from colleagues; 7 = School psychologist; 8 = Therapist.

Figure 17 – Distribution of the Sources of Satisfaction



Note. 1 = Remuneration; 2 = Career opportunities; 3 = Relationship with students; 4 = Intellectual stimulation; 6 = Students' learning; 7 = Colleagues teamwork.

8.3.2 Principal Component Analysis

A PCA was conducted separately for each of the three questionnaires (risk factors, strategies to deal with stress, and sources of satisfaction). PCA assumptions were met in all three questionnaires. The KMO was .79, .55, and .74 for the risk factors, strategies to deal with stress, and sources of satisfaction questionnaire, respectively. Bartlett's test of sphericity was significant for all three questionnaires ($p < .001$), confirming the presence of sufficient correlations among variables. Determinants of the correlation matrices ranged from .13 to .16, indicating no significant multicollinearity issues.

Based on theoretical considerations and model fit criteria, a four-component solution was retained for the risk factors and strategies to deal with stress questionnaires. In contrast, a two-component solution was identified for sources of satisfaction. For risk factors, we identified four components: school-related, school-relationship-related, bureaucracy-related, and personal life-

related risk factors. For strategies to deal with stress, we identified four components: colleague support, personal care, psychological support, and informal relationships. For sources of satisfaction, we identified two components: job activity-related satisfaction and career-related satisfaction. Standardized loadings and variance explained for all components are reported in Table 10.

Table 10 – Standardized Loadings and Explained Variances for All Principal Components for the Three Questionnaires

Risk factors						
Item	School-related stress	Bureaucracy-related stress	School relationship-related stress	Personal life-related stress	H2	
4	.90					.77
6	.81					.69
5	.70					.59
7		.83				.68
9		.79				.60
8		.53				.57
2			.88			.75
3			.75			.66
1				.97		.94
Variance	.23	.19	.15	.12		-
Protective factors - Strategies to deal with stress						
Item	Personal care	Colleague support	Informal relationships	Psychological support	H2	
5	.96					.91
4	.95					.90
1		.90				.81
6		.87				.78
3			.84			.75
2			.84			.74
8				.84		.74

7			.70	.72
Variance	.23	.21	.19	.15
Protective factors - Sources of satisfaction				
Item	Job activity-related satisfaction		Career-related satisfaction	H2
6	.87			.74
4	.84			.70
5	.79			.66
7	.48			.35
2			.86	.75
3			.80	.68
1			.80	.62
Variance	.34		.30	

Note. H2 = communality.

8.3.3 Bivariate Correlations

We examined the correlations (Pearson's r) between the extracted components (see Table 11). Correlations ranged from $|.03|$ to $|.36|$, indicating small-to-moderate associations. This suggests that while the components are related, they represent distinct factors. Furthermore, several components were significantly associated with cumulative perceived stress: school-related stress ($r = .34$; $p < .001$), school relationship-related stress ($r = .22$; $p < .001$), bureaucracy-related stress ($r = .36$; $p < .001$), personal care ($r = -.12$; $p < .001$), informal relationships ($r = .12$; $p < .001$), job activity-related satisfaction ($r = -.09$; $p < .001$), and career-related satisfaction ($r = -.17$; $p < .001$). These findings further support the use of extracted components as independent predictors of cumulative perceived stress.

Table 11 – Bivariate Correlations (Pearson’s r) Between Cumulative Perceived Stress and All the Components Identified Through PCA.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Cumulative perceived stress	—									
2. School-related stress	.34 *	—								
3. School relationship-related stress	.22 *	.22 *	—							
4. Bureaucracy-related stress	.36 *	.36 *	.23 *	—						
5. Personal life-related stress	.02	.17 *	.03	.06	—					
6. Personal care	-.12 *	-.09 *	.05	-.04	-.1 *	—				

7. Colleague support	0	.09 *	-.16 *	.07	.08 *	.09 *	—			
8. Informal relationships	.12 *	.11 *	.18 *	.11 *	.05	.1 *	.16 *	—		
9. Psychological support	.03	.08 *	.13 *	.04	.12 *	.12 *	.07	.05	—	
10. Job activity-related satisfaction	-.09 *	-.22 *	-.11 *	-.07	.01	.22 *	.26 *	.08 *	.07	—
11. Career-related satisfaction	-.17 *	.07	-.07	-.18 *	.17 *	.15 *	.19 *	.12 *	.12 *	.14 *

Note. $p < .001$

8.3.4 Proportional-odds Logistic Regression Analysis

Five proportional-odds logistic regression models were run and compared using a hierarchical approach to test whether adding different individual and contextual variables increases the explained variability in cumulative perceived stress (see Figure 1 for a graphical representation of our model). The components extracted through PCA were used as indicators of risk factors (added in model 3) and protective factors (strategies to deal with stress added in model 4 and sources of satisfaction added in model 5). Given the theoretical relevance of all the components identified, all of them were used in the regression models. Model comparison is reported in Table 12. The results showed that each component significantly improved the model, resulting in the final model (e.g., where all predictors are included) that best fits the data.

Table 12 – Results of the Model Comparison for the Hierarchical Regression Analysis. Each Model was Tested Against the Previous One (e.g., model 2 vs model 1)

<i>Model</i>	<i>Predictors added</i>	<i>Residual DF</i>	<i>LRS</i>	<i>p-value</i>	<i>AIC</i>	<i>R²</i>
1	+ Demographic and role-related variables	1890			6707.98	.03
2	+ Contextual school characteristics	1882	20.34	< .01	6703.64	.04
3	+ Risk factors	1878	390.29	< .001	6321.35	.22
4	+ Protective factors (strategies to deal with stress)	1874	41.04	< .001	6288.30	.24

5	+ Protective factors (sources of satisfaction)	1872	39.45	< .001	6252.85	.26
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Note. DF = degrees of freedom, LRS = likelihood ratio statistics. Each model was compared to the previous one (e.g., 2 vs 1; 3 vs 2).

We used this model to explore which variables were significantly associated with cumulative perceived stress when accounting for all the other variables. The model explained 26% of the variance (Nagelkerke's R^2) in perceived stress. The non-significant p-value from the Lipsitz test ($p = 0.47$) indicated that the model adequately fit the data. The results showed that teachers with more experience reported higher levels of cumulative perceived stress ($OR = 1.19, p < .002$). Moreover, three risk factors were significantly positively associated with cumulative perceived stress: school-related stress ($OR = 1.67, p < .001$), school relationship-related stress ($OR = 1.18, p < .02$), and bureaucracy-related stress ($OR = 1.59, p < .001$). While lower personal care was associated with a higher probability of reporting higher levels of cumulative perceived stress ($OR = .82, p < .001$), an opposite relation was found between informal relationships and cumulative perceived stress ($OR = 1.19, p < .001$). Finally, career-related satisfaction was negatively associated with stress ($OR = .75, p < .001$). The complete results are reported in Table 13.

Table 13 – Results of the Proportional-odds Logistic Regression Analysis (model 5)

<i>Predictor</i>	β	<i>SE</i>	<i>t-value</i>	<i>p_value</i>	<i>Odds Ratio</i>
<i>Gender (Women)</i>	0.26	0.21	1.25	0.21	1.30
<i>Years of experience</i>	0.17	0.05	3.28	< 0.002	1.19
<i>Teach Role (Classroom teachers)</i>	0.01	0.09	0.15	0.88	1.01
<i>Teaching contract (Tenured)</i>	0.19	0.11	1.66	0.10	1.21
<i>Grade (Primary School)</i>	-0.05	0.12	-0.45	0.65	0.95
<i>Grade (Middle School)</i>	-0.05	0.12	-0.45	0.65	1.05
<i>Grade (High School)</i>	-0.34	0.14	-2.32	0.02	0.72
<i>School SES</i>	0.19	0.10	1.81	0.07	1.21
<i>School Multicultural (Party Yes)</i>	-0.08	0.10	-0.79	0.43	0.93
<i>School Multicultural (No)</i>	-0.03	0.12	-0.28	0.78	0.97
<i>School Context (Suburban)</i>	0.11	0.10	1.07	0.29	1.11
<i>School Context (Rural)</i>	-0.26	0.13	-2.00	0.05	0.77
<i>School-related stress</i>	0.51	0.05	10.18	< 0.001	1.67
<i>School relationship-related stress</i>	0.16	0.05	3.46	< 0.002	1.18
<i>Bureaucracy-related stress</i>	0.46	0.05	9.58	< 0.001	1.59
<i>Personal life-related stress</i>	-0.05	0.04	-1.01	0.29	0.96
<i>Colleague support</i>	-0.04	0.05	-0.98	0.35	0.96
<i>Personal care</i>	-0.20	0.05	-4.51	< 0.001	0.82

<i>Psychological support</i>	0.03	0.04	0.79	0.43	1.04
<i>Informal relationships</i>	0.18]	0.05	4.04	< 0.001	1.19
<i>Job activity-related satisfaction</i>	0.07	0.05	1.46	0.15	1.07
<i>Career-related satisfaction</i>	-.29	-0.05	-6.20	< .001	0.75

8.4 Discussion

This study investigated which factors are primarily associated with Italian teachers' cumulative perceived stress, simultaneously considering individual, contextual, and psychosocial factors. Using a hierarchical regression analysis, we identified the specific contribution of key risk and protective factors that influence teachers' stress. The findings contribute to understanding the multidimensional nature of teacher stress, aligning with global research while also providing insights specific to the Italian educational context.

As a first step (RQ1), we examined the most reported risks and protective factors. Our findings revealed that teachers experience high levels of cumulative perceived stress, aligning with prior research showing that teaching is one of the most stressful professions (Day & Gu, 2010; Pyhältö et al., 2021). Among the most frequently reported risk factors, school bureaucracy and lack of social recognition emerge as major contributors to teacher stress. First, these findings align with previous research indicating that excessive administrative workload increases teachers' frustration, reducing instructional time (García-Carmona et al., 2019). Second, our results align with studies that revealed teachers often feel undervalued and underappreciated for their professional contributions, which exacerbates job dissatisfaction and burnout (Viac & Fraser, 2020). Research also suggests that limited professional acknowledgment negatively impacts teacher motivation and well-being, contributing to emotional exhaustion and reduced job satisfaction (Hakanen et al., 2006; Fiorilli et al., 2019). Overall, our results support and update what has been previously found in the Italian context, in which

bureaucratic overload and the undervaluation of the teaching profession have been highlighted as systemic challenges affecting educators' stress levels and job engagement (OECD, 2019; García-Carmona et al., 2019). For what concerns protective factors, teachers most relied on informal support from colleagues and family, in line with research emphasizing the role of social networks in coping with stress (Hakanen et al., 2006; Daniilidou & Platsidou, 2022; Mancini et al., 2022). However, professional psychological support was rarely used, mirroring previous findings on its limited accessibility in schools despite its effectiveness in preventing burnout (Richards et al., 2016; Montgomery & Rupp, 2005). Finally, despite high stress levels, teachers found intense satisfaction in student relationships and intellectual stimulation, reinforcing evidence that intrinsic aspects of teaching enhance motivation and resilience (Hakanen et al., 2006; Jennings & Greenberg, 2009).

Concerning our second RQ, we examined whether risk and protective factors could be grouped in broader categories (RQ2). Therefore, we conducted three PCAs, one for each of the three questionnaires administered to the teachers. Although PCA is an exploratory approach, the identified components are consistent with previous literature (Kyriacou, 2001). The four categories of risk factors identified through PCA partly overlap with Duggan's (1997) categories: school-related (which includes dealing not only with students and their needs but also with their families), bureaucracy-related (which includes organizational stressors), school relationship-related (which includes interpersonal relationships with colleagues and school principal), and personal factors (while in Duggan's model, this category included self-esteem and status concern, in our questionnaire we included a single item of general life problems). Moving to protective factors, in line with previous literature (Daniilidou & Platsidou, 2022), four strategies to deal with stress were identified: self-care, seeking support from colleagues, seeking support from other relationships (i.e., friends or family), and seeking professional support from psychologists. Finally, sources of satisfaction were grouped into two categories: job activity-related and career-related satisfaction. Job activity-related satisfaction encompasses intrinsic rewards associated with teaching activities, such as the intellectual stimulation from preparing teaching materials, satisfaction derived from students' learning progress,

and effective teamwork with colleagues. In contrast, career-related satisfaction includes extrinsic rewards stemming from the external recognition of the teaching profession, such as remuneration, opportunities for career advancement, and social recognition of the teacher role (i.e., Baroudi et al., 2020).

Finally, we examined the associations between risk and protective factors and cumulative perceived stress (RQ3) using bivariate correlations and a proportional-odds logistic regression analysis. Bivariate correlations showed that several components extracted from the PCA were significantly associated with cumulative perceived stress. We then compared five hierarchical models, each adding specific variables associated with teacher cumulative stress: demographic and role-related variables, contextual school characteristics, risk, and protective factors. Our results showed that each component significantly improved the variance explained by the model, suggesting that multiple factors influence stress and that each may play an important role. While research usually focuses on specific factors (Kyriacou, 2001; Montgomery & Rupp, 2005; Skaalvik & Skaalvik, 2011), our analysis highlights the importance of developing comprehensive frameworks that consider the joint contribution of individual and contextual antecedents of cumulative perceived stress.

In the last part of our study, we examined the entire model, which included all five blocks of stress antecedents. This analysis allowed us to identify which factors may play a more significant role when accounting for all the others. The results revealed that teachers with more experience reported higher levels of cumulative perceived stress. The relationship between teaching experience and stress is controversial (i.e., Mancini et al., 2022). On one hand, our findings contrast with studies suggesting that experienced teachers are better equipped to manage stress due to developed coping mechanisms (Klassen, 2010). On the other hand, recent findings revealed that teachers' experience was positively associated with emotional exhaustion (Mancini et al., 2022). These results may reflect the specific challenges within the Italian educational system, where prolonged exposure to bureaucratic burdens and insufficient systemic support (OECD, 2019) exacerbate stress over time.

The significant association between perceived stress and key risk factors, including school-related stress, school-relationship-related stress, and bureaucracy-related stress, is consistent with previous research emphasizing the pivotal role of organizational and relational challenges in teacher well-being (Grayson & Alvarez, 2008). These findings align with the four broad categories of stressors identified by Duggan (1997), reinforcing that teacher stress is a multifaceted phenomenon influenced by various interrelated demands. School-related stress, encompassing workload, classroom management difficulties, and student behavior, has long been recognized as a major contributor to teacher burnout (Kyriacou, 2001; Skaalvik & Skaalvik, 2017). Research has shown that teachers facing excessive workload demands and increasing classroom complexities experience heightened emotional exhaustion and reduced job satisfaction, ultimately affecting their ability to provide high-quality instruction (Hakanen et al., 2006; Pyhältö et al., 2021). These stressors are particularly pronounced when educators have limited autonomy over curriculum design and instructional methods, leading to more pressure and frustration (Bakker & Demerouti, 2007). Similarly, school-relationship-related stress, which includes strained interactions with colleagues, school leaders, and students' families, has been widely reported as a critical factor affecting teacher well-being (Wolgast & Fischer, 2017). Poor collegial relationships and unsupportive leadership can foster a sense of isolation, making teachers feel undervalued and lacking the necessary support to navigate their professional challenges (Grayson & Alvarez, 2008; Pearson & Moomaw, 2005).

Furthermore, conflicts with students' families, often stemming from mismatched expectations and communication barriers, have been identified as additional stressors that can exacerbate emotional exhaustion (Johnson et al., 2020). Previous studies have highlighted that when teachers perceive a lack of cooperation and recognition from school leadership and families, their motivation and commitment to the profession decline, increasing the risk of burnout and attrition (Collie et al., 2012; Hascher & Waber, 2021). Moreover, bureaucracy-related stress, another significant predictor of perceived stress, aligns with findings from international studies indicating that excessive administrative burdens detract from teaching and contribute to frustration and job dissatisfaction

(García-Carmona et al., 2019; OECD, 2019). Teachers frequently report that rigid procedural requirements, extensive paperwork, and accountability measures reduce the time available for instructional planning and student engagement, ultimately leading to feelings of inefficacy and professional disillusionment (McCarthy, 2019; Viac & Fraser, 2020). In the Italian educational system, where bureaucratic inefficiencies and rigid institutional frameworks are particularly pronounced, the administrative workload has been cited as one of the primary sources of professional distress (Mancini et al., 2022; OECD, 2019).

Conversely, personal care strategies, as a protective factor, were associated with lower levels of perceived stress. These strategies, such as engaging in self-care routines or leisure activities, further enhance teachers' ability to maintain emotional balance and cope with stress, as highlighted by studies on work-life integration and teacher well-being (Hakanen et al., 2006; Hobfoll, 2001). Interestingly, our results show a counterintuitive positive relationship between informal relationships and perceived stress levels. Indeed, the observed positive association suggests that teachers who engage more frequently in informal relationships seek social outlets to respond to heightened perceived stress levels. This aligns with research suggesting that individuals under stress often turn to social networks for emotional support, indicating that informal relationships may be a coping strategy rather than a stress-preventive mechanism (Hakanen et al., 2006; Hobfoll, 2001). This behavior is consistent with the "tend-and-befriend" response, where individuals, particularly women, manage stress by seeking social support and nurturing relationships (Taylor et al., 2000). This response is linked to the release of oxytocin, a hormone that promotes bonding and has calming effects. Moreover, studies have shown that perceived social support can reduce symptoms of depression and anxiety, supporting the idea that individuals turn to their social networks to cope with stress (Roohafza et al., 2014).

Our model further included the two sources of satisfaction identified through the PCA (job activity and career-related satisfaction). While most research on teacher stress is focused on reducing the impact of sources of stress and fostering teachers' strategies to deal with it (Kyriacou, 2001; Montgomery & Rupp, 2005), it is also essential to consider the role that positive contextual elements

may have in improving teachers' well-being and satisfaction. Our results showed that there is indeed a negative association between career-related satisfaction and stress, underscoring the need to enhance professional growth opportunities and recognition for Italian teachers (Lazzari et al., 2015). Career satisfaction, which often derives from opportunities for professional development, intellectual engagement, and a sense of accomplishment, has been repeatedly shown to play a pivotal role in reducing stress and preventing burnout (Hakanen et al., 2006; Klassen & Chiu, 2011). In Italy, where career pathways for teachers are often limited and advancement opportunities are scarce, dissatisfaction can exacerbate stress, leading to higher attrition rates and lower workplace morale (OECD, 2019). Moreover, studies conducted in European contexts highlight that professional recognition - such as acknowledgment of achievements and contributions to the school community - serves as a powerful motivator, counteracting feelings of undervaluation and emotional exhaustion (Pearson & Moomaw, 2005). Finally, our findings indicated that job-activity-related satisfaction significantly negatively predicts cumulative perceived stress. This suggests that teachers who derive greater intrinsic rewards from their work experience have lower stress levels. This aligns with previous research highlighting the protective role of job satisfaction in buffering against occupational stress and burnout (Hakanen et al., 2006; Klassen & Chiu, 2011). Specifically, intellectual stimulation and student progress have been identified as key factors enhancing teachers' motivation and resilience (Jennings & Greenberg, 2009; Skaalvik & Skaalvik, 2017). The sense of fulfillment derived from engaging in teaching activities and witnessing students' development fosters a stronger sense of purpose, mitigating stress and emotional exhaustion (Collie et al., 2012; Hascher & Waber, 2021).

8.5 Practical implications

Our findings underscore the urgent need for targeted interventions to mitigate teacher stress by addressing systemic risk factors and enhancing protective resources. The Cumulative Stress Model (Mann et al., 2021) used in this study reinforces that stress results from the prolonged accumulation of multiple interacting factors rather than isolated stressors. This perspective highlights the necessity

of designing comprehensive and targeted interventions, addressing different dimensions of teacher stress simultaneously rather than focusing on single stressors in isolation.

First, the high cumulative stress teachers report highlights the need to reduce bureaucratic burdens. Excessive administrative tasks detract from instructional time and increase frustration (McCarthy, 2019), making it essential to streamline paperwork and administrative procedures. Second, the lack of professional recognition and career growth opportunities emerged as key stressors (Pearson & Moomaw, 2005). Investing in structured career pathways, mentorship programs, and formal recognition initiatives could improve job satisfaction and retention. Third, while informal support from colleagues and family played a protective role, the low use of professional psychological support (Montgomery & Rupp, 2005) suggests accessibility barriers. Expanding school-based psychological services and raising awareness of mental health resources could enhance teachers' coping capacities. Finally, interventions should leverage key sources of job satisfaction, such as relationships with students and intellectual engagement, which buffer against stress (Hakanen et al., 2006; Jennings & Greenberg, 2009). Professional development should promote strategies that foster engagement while easing classroom management challenges (Simonsen et al., 2008).

Our findings suggest that a cumulative stress framework underscores the need for multi-level, targeted interventions that address systemic stressors while reinforcing protective factors, fostering teacher well-being, and sustaining a resilient educational workforce.

8.6 Limitations

However, this study is not without limitations. First, the reliance on self-reported measures may have introduced response biases, potentially inflating associations between variables. Additionally, the cross-sectional design precludes causal inferences, leaving the temporal dynamics of risk and protective factors unexplored. Third, the measure was developed specifically for this study and tailored to the Italian context, but it has not been previously validated. For this reason, we examined single items in this study. We employed a PCA to identify meaningful components within

each questionnaire, recognizing that PCA does not assume the presence of latent factors. Future research should replicate our findings using validated measures to ensure the robustness and generalizability of the results.

Another limitation of the present study is that we did not examine the effects of interaction between risk and protective factors. Following the cumulative stress model (Mann et al., 2021), we focused on the additive contribution of individual and contextual factors to perceived stress. However, other models have already considered that risk and protective factors may interact (Woods et al., 2023). Given the large number of predictors involved in our study and the use of a single item for the dependent variables, we did not explore interaction effects. Future research should explore these interactions to provide a more nuanced understanding of how different factors jointly influence stress.

Finally, the focus on Italian teachers, while valuable for addressing a research gap, limits the generalizability of the findings to other cultural and educational systems. Future research should address these limitations by employing longitudinal designs and exploring comparative studies across diverse educational contexts. Investigating the long-term effects of interventions to reduce bureaucracy and enhance career satisfaction would provide deeper insights into strategies for improving teacher well-being. Moreover, in future research, we encourage the replication of studies like ours in different national contexts. Given the unique characteristics of each country's educational system and working conditions, collecting country-specific data is essential for accurately mapping both challenges and strengths. Such comparative efforts would provide a more comprehensive understanding of teacher stress and contribute to developing targeted intervention strategies tailored to the specific needs of each context.

8.7 Conclusions

This study comprehensively analyzes the cumulative perceived stress experienced by Italian teachers, identifying key risk and protective factors that shape their well-being. Our findings reveal that high stress levels are primarily associated with bureaucratic overload, lack of social recognition,

and relational challenges within the school environment, reinforcing existing research on the organizational and interpersonal demands of the teaching profession. At the same time, we highlight the significant role of protective factors, such as informal social support and job-activity-related satisfaction, in buffering against stress. Notably, we found that intrinsic rewards linked to teaching activities, including intellectual stimulation and student progress, are crucial in reducing stress levels. These insights contribute to the existing literature by offering a cumulative perspective on teacher stress. By addressing these challenges through systemic interventions — reducing administrative burdens, fostering professional recognition, and enhancing opportunities for meaningful engagement — educational policies can better support teacher well-being and retention, ultimately improving the overall quality of the educational system.

Chapter 9 | General Discussion

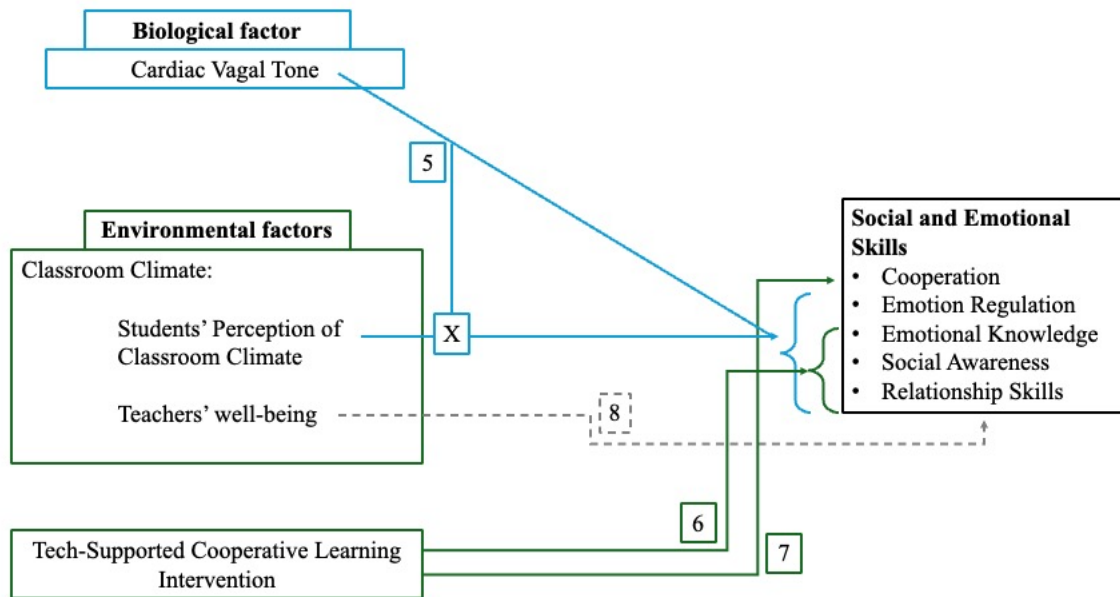
This dissertation presents a comprehensive investigation into the development of social and emotional skills in school-aged children, framed within a biopsychosocial perspective. Across four empirical studies, it examines how biological regulation, psychological perceptions, and socio-environmental factors interact to influence students' SES. By combining psychophysiological indicators, such as CVT, with subjective classroom experiences and intervention strategies, this work provides a detailed understanding of how SES are formed and can be intentionally promoted in schools. Two additional exploratory studies expand the model by considering teachers' emotional and professional resources, emphasizing their role as key contextual factors in students' development. In this final chapter, I will review the key findings from each study, discuss their implications and limitations, and suggest future research directions and practical applications for education.

9.1 Overview of the Main Findings

This dissertation adopted a biopsychosocial approach to understanding SES development, emphasizing the dynamic interplay between biological and environmental factors. Its main aim was to investigate how internal regulation, measured by CVT, and external classroom conditions, such as climate, instruction, and teacher variables, influence SES growth. The overall thesis also aimed to identify scalable strategies for enhancing these skills within real-world school settings.

As shown in Figure 3 of Chapter 4 (reported below, too), this thesis explored how environmental and personal factors may affect the development of social-emotional skills in school-age children.

Figure 3 of Chapter 4 – The Biopsychosocial Model Tested in the Present PhD Project



Note: Numbers refer to the number of Chapters.
 Continuous lines represent the associations tested, while dashed lines represent assumed relationships that were not tested.

As discussed in the introduction, after early interactions with caregivers, children develop their SES through continuous interaction with their broader environment (Sameroff, 2010). Schools are one of the most important environments, and the interactions taking place within the classroom shape students’ development of socio-emotional competencies (Hamre & Pianta, 2006; Wang et al., 2020). Neuroscience reveals that the amygdala and prefrontal cortex mature at different rates and that their functional integration, which is crucial for emotion regulation and flexible social behavior, continues to develop across middle childhood into adolescence (Casey, 2015; Gee et al., 2013; Tottenham, 2017). Because the amygdala is especially sensitive to emotionally salient social cues early in life and its experiential history helps shape amygdala–prefrontal circuitry, sustained, structured social-emotional learning in schools can scaffold adaptive circuit development; these socio-emotional skills are formed by the environment precisely because one of their core roles is to make the individual better able to adapt to that environment (Tottenham 2015, 2017; Domitrovich et al., 2017; OECD, 2021b).

With this in mind, we assessed CVT as a biological correlate of the individuals' ability to self-being. On the side, as an environmental element, it also tested the effects of a tech-supported CL intervention to promote SES by integrating its development with academic skills.

Specifically, the first study (Chapter 5) assessed the direct and interactive effects of cardiac vagal tone and students' perception of classroom climate on SES development. Then, the direct impact (with a control group) of the tech-supported CL intervention on SES were measured both through self-report (second study, Chapter 6) and behavioral tasks (third study, Chapter 7).

In general, the model supported the joint role of cardiac vagal tone and classroom climate on SES. The direct effect of CVT on SES was not detected, consistent with the literature, which increasingly considers CVT as a moderator of self-regulation development. On the other hand, the direct effect of classroom climate on SES emerged, highlighting the importance of fostering a positive social and emotional climate in the classroom to support the development of SES in students. Finally, and most importantly, the interaction between the two emerged as significant, revealing that classroom climate is very protective for students with good self-regulation skills, while not sufficient for those with self-regulation difficulties and therefore low CVT. In addition, the tech-supported CL intervention was found to be effective in developing emotional knowledge, social awareness, relationship skills (all measured through self-report) and cooperation (measured through a behavioral task). Specifically, the main results will be summarized and discussed below.

Chapter 5 explored the interaction between individual physiological traits and environmental factors in shaping students' SES, using a biopsychosocial perspective. The focus was on cardiac vagal tone as a physiological marker of self-regulation, as well as students' perceptions of classroom climate as a key environmental factor. SES was measured through self-report items aligned with four CASEL domains (excluding responsible decision-making), while CVT was assessed via resting rMSSD, a validated cardiac vagal tone indicator. Students also reported their perception of classroom climate using a validated measure (CHIP-CE, Riley et al., 2004). Results showed that CVT alone did not significantly predict SES, indicating that physiological self-regulation alone may not explain

differences in social and emotional skills. However, perceived classroom climate had a significant positive impact on SES, highlighting its role as a vital developmental context. Notably, an interaction was found: the positive effect of classroom climate on SES was stronger for students with higher CVT. Conversely, students with lower CVT appeared less able to benefit from positive environments, possibly due to fewer internal regulatory resources. This supports the idea that SES development depends on the interaction between internal readiness and external support. It also emphasizes the importance of a multimethod approach, combining psychophysiological data and subjective perceptions, for assessing socio-emotional functioning in schools.

Chapter 6 investigated whether a technology-supported CL intervention, delivered via the PeerLearning.net platform, can effectively promote SES among primary and middle school students in Italy. An experimental design was used, involving 36 classrooms randomly divided into intervention and waitlist control groups. Teachers in the intervention group received training and ongoing support to carry out 16 structured CL lessons throughout the school year, each focusing on specific SES skills. SES levels were measured at two points using a validated self-report questionnaire (WCSD-SECA, Davidson et al., 2018). Results showed a significant interaction between time and group: students in the intervention improved more in SES compared to the control group. Although the overall change was small, it was statistically significant and aligned with previous studies, indicating the intervention's potential as a scalable, preventive approach for integrating SES into daily academic activities. This chapter demonstrates that technology-facilitated CL, when properly implemented with fidelity and scaffolding, can support meaningful social-emotional development even in complex educational environments.

Chapter 7 aimed to reassess the effects of a tech-supported CL intervention, this time measuring SES as cooperation in a behavioral task. The same sample and procedure from Chapter 6 were used. Cooperation was assessed through a tablet-based version of the classic Marble Pull Game (Madsen, 1971), which evaluated not only the success rate of coordination but also its fairness and mutuality. Results showed a significant time-by-group interaction: while cooperation improved in

both groups, the intervention group saw notably larger gains. These findings indicate that cooperative behavior is not just a natural development with age or experience but can be intentionally fostered through well-structured, fidelity-focused teaching methods. Using a behavioral measure marks an important step forward, overcoming the limitations of previous studies that relied only on self-reports. Additionally, providing job-shadowing support for teachers improved implementation consistency, highlighting the importance of integrated, scalable training when introducing complex instructional strategies.

Chapter 8 provided an initial look into Italian teachers' emotional and professional resources, showing high stress levels, their sources of stress, and possible protective factors. These results support the Prosocial Classroom Model (Jennings & Greenberg, 2009), which suggests that teachers' psychological well-being is crucial for creating classroom environments that support students' emotional and social growth.

Overall, the model examined in this dissertation emphasizes the significant roles played by both individual and environmental factors in the cultivation of students' social and emotional competencies. Notably, classroom climate has been shown to be a robust and consistent predictor of socio-emotional skills, particularly for students exhibiting higher levels of cardiac vagal tone. Nonetheless, the findings also underscore a critical nuance: for students with lower vagal tone, a positive classroom climate alone may not be enough. These students might benefit from more targeted and individualized support to activate and enhance their regulatory resources. Concurrently, the technology-supported cooperative learning intervention demonstrated clear promise, facilitating improvements in emotional understanding, social awareness, and cooperation among students. Collectively, these findings support the perspective that scalable, structured approaches — particularly when integrated into authentic classroom environments — can provide a practical and effective pathway for fostering students' social and emotional development.

9.2 Limitations and Further Directions

Although this dissertation employs a thorough and multi-method approach, it is essential to acknowledge certain limitations. The following considerations are crucial for interpreting the findings and identifying priorities for future research.

Initially, this research adopted a biopsychosocial approach, integrating biological and environmental factors (Engel, 1997; Sameroff, 2010). However, some methodological limitations remain. Notably, social and emotional skills were mainly evaluated through self-report questionnaires. Though these are standard and validated tools (Davidson et al., 2018), they are susceptible to social desirability biases, cognitive distortions, and developmental challenges, especially in middle and late childhood when children might lack the metacognitive ability to assess their skills accurately (Crowder et al., 2019; Denham, 2015). While the behavioral cooperation task from Chapter 6 partly addresses this concern, future studies should incorporate more observational methods, such as behavioral coding, and physiological measures (Domitrovich et al., 2017).

Second, although age was included as a covariate in most analyses, its effect was not significant. This may be due to the narrow age range of the samples (mostly 8–11 years). Still, it also prompts the question of whether SES development, classroom climate, or physiological reactivity evolve differently across developmental stages. Future research should specifically examine age-related differences, preferably with developmentally stratified approaches to offer more targeted educational guidance.

Third, this study explored SES solely from the student's perspective. While this focus is essential, it does not reflect how teachers perceive, value, or evaluate SES in their students. Future research should include multiple viewpoints, ideally incorporating data from students, teachers, and possibly caregivers, to provide a more comprehensive view of social-emotional development (Bronfenbrenner, 1979).

Fourth, there are two main limitations to the generalizability of the findings. First, since the studies were conducted in specific regions of Northern Italy, variations in school organization, teacher

training, and classroom culture may exist compared to other parts of the country. Second, the absence of comparative data from different European or Mediterranean countries hampers understanding of whether these effects are applicable elsewhere. Future research should focus on replicating these results across diverse socio-cultural contexts, ideally through international collaborations.

In the two intervention studies (Chapters 6 and 7), there was no active control group that implemented cooperative learning without technological support. Consequently, while the results support the effectiveness of the PeerLearning.net software, we cannot conclusively determine if the observed effects are due to the technological scaffolding itself or to cooperative learning in general. Future studies should include three groups — tech-supported CL, traditional CL, and instruction-as-usual — to accurately identify the specific impact of digital facilitation (Van Ryzin & Roseth, 2019).

Sixth, the lack of long-term follow-up is a limitation in assessing whether SES improvements are sustainable over time. Although the post-intervention gains were encouraging, it remains unclear whether students continued to benefit from these skills after the study concluded. Since long-term outcomes are crucial for educational and health policies, future studies should include longitudinal assessments of SES maintenance, focusing on academic progress, social adaptation, and well-being (Jones et al., 2015; Taylor et al., 2017).

Ultimately, the job shadowing approach to assist teachers in adopting tech-supported CL demonstrated promise in enhancing fidelity and motivation. Yet, its scalability remains uncertain. Providing such intensive professional development requires significant financial and human resources, which are often limited in many schools. Future research should examine more affordable modifications or hybrid models, such as digital coaching or peer mentoring systems.

9.3 Relevance of This Dissertation and Practical Implications

Overall, the studies in this dissertation offer a comprehensive contribution to the ongoing discussion on how schools can effectively promote students' social and emotional skills. From a

biopsychosocial perspective, the results highlight that SES development cannot be understood through a single factor. Instead, it demands a systemic and integrated approach that considers the interaction between students' personal traits (like physiological indicators of self-regulation) and the quality of their educational environments.

Initially, findings from this dissertation reinforce the notion that classroom climate serves a vital regulatory role, especially for students exhibiting higher CVT levels. These students tend to be more attuned to interpersonal signals and are thus more receptive to environments that are emotionally safe and responsive (Perry et al., 2016; Wang et al., 2020). For these students, a well-structured, emotionally supportive classroom can act as a scaffolding environment facilitating socio-emotional development.

Second, early detection is especially crucial for students with lower vagal tone, since they might not respond as well to positive classroom climates. The data indicate that, although a supportive environment benefits everyone, it alone is not enough for students with lower biological predispositions for emotional regulation. These students may require additional, customized interventions, including targeted classroom strategies and specialized emotional support.

Third, this dissertation highlights that cooperative learning, particularly when supported by technology and structured effectively, is a promising approach for fostering key SES components. The evidence presented here supports earlier research (Johnson & Johnson, 2009; Van Ryzin & Roseth, 2019a, b), which shows that CL — when applied according to its core principles — can enhance emotional understanding, social awareness, relationship skills, and cooperation. Tech-enhanced settings, like those on the PeerLearning.net platform, improve the accuracy of implementation and lessen teachers' logistical workload (Low & Van Ryzin, 2024), while still engaging students in meaningful peer activities that build SES.

Fourth, for teachers to effectively teach SES, they need proper training and continuous support. Professional development should offer both emotional well-being resources and opportunities for co-teaching through job-shadowing, allowing teachers to observe and practice

implementing CL and scaffolding SES in actual classrooms. This practical approach can help address the frequent view that SES instruction is too time-consuming or secondary to core academic work.

Fifth, teachers should be encouraged to take on the role of assertive-metacognitive tutors—adults who support students within their Zone of Proximal Development (Vygotsky, 1978) and actively scaffold the development of SES, rather than passively waiting for these skills to emerge. These teachers do more than react to behavior; they create learning environments that intentionally promote SES, guiding students in how to listen, collaborate, and manage emotions.

Sixth, SES development should go beyond isolated programs or extracurricular activities. It should be integrated into the standard school curriculum, particularly in primary and middle school, as a core element of education (Domitrovich et al., 2017). This integrated strategy is crucial to ensure lasting effects and prevent social-emotional learning from becoming secondary or optional.

Ultimately, schools alone cannot overcome this challenge. Educational policies need to acknowledge that promoting SES in diverse and emotionally intricate classrooms demands collaboration across disciplines. The complexity and diversity of today's classrooms require a shift toward collaborative professional models. Psychologists, pedagogists, and special educators should partner with teachers to jointly design and implement effective learning environments. This multi-professional strategy could be crucial in addressing the increasing diversity and complexity within student populations, which are among the biggest obstacles to SES development.

9.4 Conclusions

In conclusion, this dissertation contributes to the growing body of research on how social and emotional skills can be supported and developed in school contexts, offering both theoretical and practical insights grounded in a biopsychosocial model. The studies presented here support that SES is not a fixed trait, but a dynamic competency shaped by the interaction between internal predispositions and external environments.

From a theoretical standpoint, the findings reaffirm that understanding SES requires moving beyond single-variable approaches, thus adopting more complex model, such as the biopsychosocial one, to better understand what favors their development. In addition, they emphasize the importance of considering the child as an embedded agent whose behavior and skills emerge from ongoing interaction within a relational and environmental context. Moreover, they underline the need to employ a multi-method approach to measure SES, particularly during this age period, which is sensitive to biases and practical school-related issues.

Practically, these insights have clear implications for school-based interventions. Programs aiming to promote SES should be developmentally sensitive, tailored to individual differences in physiological regulation, and systematically embedded into classroom practice. For example, students with lower CVT may benefit from more intensive, adult-mediated interventions, while those with higher CVT appear more responsive to emotionally supportive classroom climates. Cooperative learning, especially when structured around its core principles and supported by technology, has shown promise as a scalable method for embedding SES practice into everyday instruction. However, its effectiveness depends heavily on the fidelity of implementation and the support of the teacher. That is why technology can support teachers in delivering CL, as revealed from this dissertation, considering the benefits of SES development integrated in curricula.

Finally, the emotional well-being and pedagogical efficacy of teachers must be considered a foundational prerequisite for any SES-promoting intervention.

Taken together, these studies suggest that promoting SES in schools is not a matter of isolated programs or individual traits but a systemic endeavor. It demands collaboration between disciplines, targeted support for teachers, and a reframing of SES as a developmental priority that is woven into the very fabric of daily school life.

Personal final comment

Since my very first internships in schools during my undergraduate years — when I had the opportunity to observe children’s emotional (dis)regulation in real time (for example, I remember Amira, Godswill, Mateo...) — I began to understand how much the theories I studied in books were not just abstract constructs, but tangible realities. The idea that “*we feel, therefore we learn*” (Immordino-Yang & Damasio, 2007), which I had encountered in my initial coursework, took on a concrete and powerful meaning in the everyday rhythms of classroom life.

This conviction has accompanied me throughout my academic path, from the first internship with Professor Scrimin to the final stages of this dissertation. It was during that early experience with her — watching how she observed, listened, and moved with such grounded presence between schools and research — that I realized I was beginning to read the school through the same lens. I deeply admired her ability to remain rooted in rigorous scientific inquiry while never losing touch with the reality of classrooms, students, and educators.

Later, working with Professor Ianes helped further solidify my belief that school today must radically rethink its role: no longer a place for merely “filling heads,” but one that shapes “*well-made minds*,” as Morin wrote (in Italian, *La testa ben fatta*). A “well-made mind” integrates knowledge with emotional competence and relational skills. And those social and emotional skills are not simply desirable: they are the gateway to any meaningful learning. Before children can learn how to recognize adjectives or memorize multiplication tables, they must first know how to regulate frustration, cooperate with others, and feel seen and supported. These are the conditions that make learning possible.

Having had the opportunity, through this dissertation, to investigate how such conditions can be cultivated in schools — within a systemic, biopsychosocial framework — fills me with gratitude and pride. It brings meaning to a journey that began years ago with curiosity and has grown into a commitment to research that is both applied and hopeful, deeply rooted in the real world of education.

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Appendices

Appendix I – Sample lesson plan on turn-taking during Italian text comprehension

- Target Social-Emotional Skill (SES): Turn-taking
- Cooperative Learning Structure: Group Project (task-based interdependence)
- Academic Focus: Reading comprehension (narrative text)
- Grade Level: 4th–5th grade
- Session Duration: 60 minutes
- Materials: PeerLearning.net + paper-based text comprehension

1. Explicit Instruction

The teacher introduces the social-emotional skill of turn-taking using PeerLearning.net’s dedicated module. A slide with example sentences is projected on the screen, such as:

- *“Now it’s your turn to speak.”*
- *“Let me finish, then I’ll listen to you.”*
- *“We can talk one at a time.”*

This is followed by a brief class discussion on why turn-taking is important and how it affects group dynamics. The class then sets a behavioral goal (which will be monitored by the teacher through the software, in a Positive Behavior Support manner as mentioned in the paper), e.g.,

“Each group will aim to complete at least 10 respectful speaking turns, without interrupting.”

2. Group Project Task – Reading comprehension Activity

Text used: *The Silly Little Goats* (adapted from De Beni et al., 2003)

Each student is assigned a portion of the text to read to the others. After the reading is finished, each student is assigned specific questions, calibrated to their level of proficiency. After answering, they

compare their answers with those of other classmates who had their piece of material. Afterwards, they return to their group to do reciprocal teaching. The final exercise, on the other hand, involves everyone's contribution by utilizing the information they have derived on their own.

The teacher monitors group interactions using the PeerLearning.net dashboard and awards team point each time respectful turn-taking is observed.

3. Reflection and Group Processing

At the end of the session, students enter the review phase via PeerLearning.net. This includes both an individual reflection and a group one, with questions such as “Did I feel involved in the group?”, “How much did I learn in this class?”.

This discussion is scaffolded by sentence prompts visible in the app and guided by the teacher, who facilitates honest and constructive peer feedback.

Appendix II – Social and Emotional Skills Scale adapted from the WCSD Social and Emotional Competency Long-Form Assessment (Davison et al., 2018)

How difficult or easy is it for me to...

1. Recognizing when my emotions prevent me from concentrating.
2. Identifying the emotion I am feeling.
3. Finding strategies to feel better when I am sad.
4. Noticing what happens in my body when I am nervous.
5. Understanding how my classmates feel by looking at their expressions.
6. Recognizing when people need help.
7. Understanding that my actions influence my classmates.
8. Respecting what my classmates say, even if I disagree with them.
9. Sharing with others how I feel.
10. Talking to an adult when I have problems at school.
11. Being kind even to someone I don't usually interact with.

