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The Hidden Metaphors of Learning: Crown Shyness, Mirror Neurons, and the Classroom

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Abstract: *Learning is often seen as an individual endeavor, yet it is deeply embedded in social contexts. The aim of this article is to explore the hidden metaphors of learning through three frameworks: crown shyness, mirror neurons, and social learning theories. These concepts are connected to the theories of Lev Vygotsky and Albert Bandura, as they support the idea that learning is shaped by social interaction. Crown shyness, a natural phenomenon in which trees create safe gaps between their canopies, serves as a metaphor for the balance between individual autonomy and collective growth reflected in the classroom. Similarly, mirror neurons support the biological basis of learning through observation and imitation, reinforcing Bandura's Social Learning Theory. Vygotsky's Zone of Proximal Development (ZPD) and the concept of scaffolding illustrate how guided interactions shape cognitive development. By integrating insights from the natural ecosystems and the neuroscience of learning, this article argues that effective education mirrors organic principles of growth, fostering observational learning through imitation, and empathy.*

Keywords: crown shyness; mirror neurons; social learning; observational learning; zone of proximal development

Introduction

Metaphors surround us, woven into the simplest actions and the most conventional gestures. They not only help us make sense of everyday life but also shape the way we perceive and construct reality. Sometimes, they even recreate it, adding new layers of meaning to concepts that are already well established (Bratianu & Bejinaru, 2023; Lakoff & Johnson, 1980). Learning, often considered a purely human journey, is not merely a social construct—it follows patterns deeply rooted in nature. From the way trees grow in harmony to the manner in which our brains mirror the actions of others, learning is a dynamic process shaped by both social interaction and environmental influences.

What can nature teach us about human learning and interaction? How do its patterns reflect the way we shape our social and cognitive experiences? The neuroscience of learning can be understood through nature-inspired metaphors, as they help us understand how observation and interaction function in classrooms. The classroom is not a static environment, but a dynamic, living ecosystem, where learning unfolds through both guidance and social exchange. Within this evolving space, metaphors reveal a delicate balance between independence and limitation, as well as the biological foundations of imitation and connection. From the canopies in a forest, those "meandering channels" (Dipanjan & Poulomi, 2018, p. 46) still not fully deciphered, to the intricate structure of our own brains, there is still much to explore and to learn from.

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The ability to imitate behaviors provides a foundation for learning and empathy, fostering both social development and cognitive growth (Snyder, 2019). Albert Bandura's Social Cognitive Theory (SCT) explains a type of learning that blends imitation and observation. Although not directly part of SCT, mirror neurons may play a role in reading people's minds, understanding their intentions, and forming social bonds (Magister, 2024). They activate not only when we observe actions, but also when we perform them (Rizzolatti & Craighero, 2004).

The phenomenon of crown shyness, where trees respect boundaries while growing, mirrors the dynamics of the classroom. Just as trees maintain space for one another, students offer the same respect to each other's boundaries, allowing for individual growth within a collaborative learning environment. This aligns with Lev Vygotsky's concept of the Zone of Proximal Development (ZPD), where learning and growth are fostered through social interaction, guidance, and scaffolding (Rahman, 2024).

Literature review

Crown shyness – from individual autonomy to collective growth

More than a visual phenomenon, these "zigzag cracks" (Dipanjan & Poulomi, 2018, p. 46) shape the forest ecosystems, influencing resources dynamics and contributing to biodiversity conservation (Bhoi, 2024). Also called canopy disengagement (Goudie et al., 2009; Thursd, 2025), crown shyness is usually seen in forests where there is a great variety of species (Dipanjan & Poulomi, 2018). It mainly occurs in trees of the same species (Putz et al., 1984; Dipanjan & Poulomi, 2018; Osterloff, 2020), such as Lodgepole pine (Goudie et al., 2009), eucalyptus, oak, and maple (Thursd, 2025). Though not restricted to a certain region, this canopy design is usually formed in old forests, as old trees support whole communities, due to the great amount of carbon they store (Baillargeion, 2020).

The term was coined in 1955 by the Australian forester and botanist Maxwell Ralph Jacobs (Moffett, 2000; Thursd, 2025), but the phenomenon had been observed by F.J.Putz (Wu, 2020; Das, 2023) since 1920 (Goudie et al., 2009; Thursd, 2025). Margaret Lowman described crown shyness as "a patchwork of green islands, separated by rivers of empty space" (in Baillargeion, 2020) and compared it to the arboreal version of social distancing (Baillargeion, 2020; Wu, 2020; Das, 2023).

Though there are a few studies to understand this phenomenon (Dipanjan & Poulomi, 2018; Das, 2023), too little is known about how and especially why crown shyness occurs. Physical contact certainly plays a vital role in the formation of these green islands (Van der Zee et al., 2021). The gaps depend on species, height and the force of the wind (Dipanjan & Poulomi, 2018). The main cause of their formation is the wind, as it moves the canopy, thus leading to abrasion (Osterloff, 2020; Wu, 2020; Bhoi, 2024). In strong wind conditions, trees suffer physical damage and stop growing (Putz et al., 1984; Dipanjan & Poulomi, 2018; Wu, 2020). But this is not the only explanation. In a research conducted in 1984, on a black mangrove in Costa Rica, the puzzle of the branches could still be seen, in the absence of winds (Osterloff, 2020). When sensing a specific frequency of light, called far-red light, trees stop growing, so as to avoid being too close to their neighbors (Dipanjan & Poulomi, 2018; Osterloff, 2020). Camphor trees can sense light and stop growing, in order to allow the light to reach the forest floor (Osterloff, 2020). Another theory is related to the fact that there is a reduction in the lateral growth, due to mutual shading, in order to respect each other's boundaries (Putz et al., 1984).

Forests are extremely dynamic in their structures, especially the canopy (Dipanjan & Poulomi, 2018). The wind and the canopy dynamics influence branch orientation and spacing (Bhoi, 2024). These "meandering channels" (Dipanjan & Poulomi, 2018, p. 46) have ecological significance that is still investigated (Bhoi, 2024), as there are few studies to fully explain the formation of the gaps. Crown shyness plays a vital role in the ecological

dynamics of the forest, being shaped by light, nutrient cycling, and species interaction (Bhoi, 2024).

Trees grow their exposure to light, optimizing the photosynthesis (Dipanjan & Poulomi, 2018; Osterloff, 2020). The gaps in the canopy allow the light to reach the floor, benefitting species of plants and animals that live in the ecosystem (Putz et al., 1984; Dipanjan & Poulomi, 2018; Osterloff, 2020; Van der Zee et al., 2021; Das, 2023; Bhoi, 2024; Thursd, 2025). Another beneficial effect is that by forming islands of canopies, trees prevent the spread of diseases between them (Dipanjan & Poulomi, 2018; Baillargeion, 2020; Osterloff, 2020; Das, 2023; Bhoi, 2024). This way resources allocation, in terms of light, water and nutrients, is favored (Wu, 2020; Das, 2023; Bhoi, 2024).

Trees use hormones, such as auxins and cytokinins, in order to foster growth (Bhoi, 2024) and they adjust their canopies when sensing neighboring trees (Wu, 2020). They also emit Phytoncides, chemicals that can lessen stress and strengthen the immune system (Das, 2023). Trees send signals to their neighbors about resources and other ecological cues (Bhoi, 2024), as their leaves are "the energy machines" of a tree and need more space to function (Baillargeion, 2020).

Mirror neurons – from observation to imitation

Mirror neuros are cells in the brain that allow us to imitate the actions of others, helping us not only to understand what people are doing, but also to learn by imitation. Humans have the ability to grasp the mental states of those around them (Bastiaansen et al., 2009), especially when there is a strong connection between them (Cunnington, 2019; Magister, 2024). We simulate the emotions of others and this ability helps us in our social interaction. We show empathy and we develop social learning (Bastiaansen et al., 2009; Cunnington, 2019; Magister, 2024). These phenomena are related to theory of knowledge fields and knowledge dynamics (Bratianu, 2022; Bratianu & Lefter, 2001). What others do can become our own experience (Rizzolatti & Craighero, 2006), and this "evolutionary foundation of human uniqueness" (Heyes, 2010a, p. 789) gained recognition more than 30 years ago, when scientists discovered that there are neurons in our brain which fire during both action execution and observation (Pellegrino et al., 1992). They activate not only when we observe actions, but also when we listen to sounds (Magister, 2024).

The first experiments were made on Macaca nemestrina monkeys in 1992 by Giuseppe Di Pellegrino (Pellegrino et al., 1992; Rizzolatti et al., 1996). Unusual neurons were discovered in the ventral premotor region F5 of these monkeys (Pellegrino et al., 1992; Rizzolatti et al., 1996; Gallese & Goldman, 1998; Gallese et al., 2004; Rizzolatti & Craighero, 2004; Blakeslee, 2006; Rizzolatti & Craighero, 2006; Iacoboni, 2009; Heyes, 2010b; Kilner and Lemon, 2013; Jeon and Lee, 2018; Ramachandran, 2022), indicating that gesture movements are correlated to discharging and firing of some neurons, not only during performing, but also observation (Pellegrino et al., 1992).

The term mirror neurons was introduced in 1996 by Giacomo Rizzolatti and his team (Rizzolatti et al., 1996) to indicate "those neurons that become active when the monkeys observed meaningful hand actions performed by the experimenters." (Rizzolatti et al., 1996, p. 134). Moreover, Rizzolatti et al. mention that a similar mechanism may exist in people, having important properties not found in monkeys (Rizzolatti & Craighero, 2004; Blakeslee, 2006). These "cells that read minds" (Blakeslee, 2006, p. 2) shape our ability to learn by observation and help us understand concepts, solve problems, all through interaction (Magister, 2024).

Mirror neurons combine sensory and motor properties in a single unit (Heyes, 2010a; Carcea and Froemke, 2019), establishing the foundation for empathy and social cognition (Kilner & Lemon, 2013; Magister, 2024), although there has been little empirical research

about the effects on social cognition (Heyes, 2010b). Also, very little is known about their development (Heyes, 2010a), but researchers consider them more than an adaptation. There isn't yet an answer to the question if they are found in our brain from birth or if they developed with experience and learning (Cunnington, 2019).

Why do mirror neurons exist? To solve the problem of other minds (Iacoboni, 2009). These "neurons that shape civilization" (Vilayanur Ramachandran – TedIndia, 2009) help us understand how our actions are formed, and how we can read others' actions (Gallese et al., 2004; Blakeslee, 2006; Rizzolatti & Craighero, 2006; Kilner & Lemon, 2013). They play a pivotal role in both action understanding and imitation (Rizzolatti & Craighero, 2004; Heyes, 2010b; Snyder, 2019; Magister, 2024), as they activate when we move our body or when we observe other people's actions (Jeon & Lee, 2018; Magister, 2024). Moreover, they help us grasp the intentions and the feelings behind these actions (Gallese & Goldman, 1998; Rizzolatti & Craighero, 2006; Jeon and Lee, 2018).

"Without action understanding, social organization is impossible." (Rizzolatti & Craighero, 2004, p. 169). Mirror neurons represent the neural basis of a mechanism which links the senders to their receivers (Rizzolatti & Craighero, 2004), as matching is their basic property (Heyes, 2010b). They form a bridge between people, matching observed actions with executed one (Heyes, 2010b; Magister, 2024). They also help us learn by associative learning. We make associations between items, events, or actions that generally happen together (Cunnington, 2019) and the mirror neuron system assists us in improving learning and acquiring new skills (Magister, 2024).

Mirror neurons mediate imitation, as this process reflects an ability which is a result of experience (Gallese et al., 2004; Catmur et al., 2009; Heyes, 2010b). We observe and we imitate, in order to learn, and mirror neurons activate, allowing us to transfer information between individuals, thus facilitating the transmission of skills and knowledge (Magister, 2024). Learning by imitation is at the core of human culture and interaction (Rizzolatti & Craighero, 2004; Giudice et al., 2009; Snyder, 2019; Ramachandran, 2022). The motor cortex becomes active when we observe an action (Rizzolatti & Craighero, 2004) and mirror neurons not only support, but are supported by human social interactions (Heyes, 2010b; Catmur et al., 2016). There is a strong relation between the degree of empathy and the amount of imitation (Iacoboni, 2009). We are more likely to imitate the actions of those models who have gained recognition, than models who have low social competencies (Bandura, 1971). As Lieberman notices, humans have the tendency of aligning their behavior with those who surround them during social interaction (Iacoboni, 2009). This happens because one of the functions of the mirror neuron system is to develop the process of mind reading, in order to anticipate other's future actions (Gallese & Goldman, 1998) and to understand people's mental states (Iacoboni, 2009; Ramachandran, 2022; Magister, 2024).

When mirror neurons activate, they create the fundamental mechanisms of our understanding of other's actions (Gallese et al., 2004) and they are shaped by our individual experiences and interactions (Catmur et al., 2009; Heyes, 2010b). These cells are mesmerizing not only for researchers, but also for non-specialists (Heyes, 2010a), since our human development would not be possible without the capacity to learn by observing how others behave (Giudice et al., 2009).

Social learning theories - from Lev Vygotsky and Albert Bandura to mirror neurons and crown shyness

Learning occurs when we see and imitate models. We learn not only from our own experience, but also from observation (Magister, 2024). Our mirror neuron system represents the crucial base for imitation and social learning (Giudice et al., 2009). This imitation is connected to understanding and cooperation with adults or peers (Rieber,

1998). It is by sharing our experiences with other people that we create stronger bonds which result in a sense of belonging (Magister, 2024). Individuals learn best when working together, because they internalize new concepts, tools, and skills (Shabani et al., 2010). There is little neurobiology research to explain how knowledge organization is expressed in the brain (Owens & Tanner, 2017). A safe learning environment is needed, where positive emotions are expressed, in order to promote growth (Ness, 2022). Mirroring processes are stronger when we observe people we are connected to, so students can't learn passively, they have to be emotionally engaged (Cunnington, 2019). The mirror neuron system activates best in real life experiences, when people connect and interact (Blakeslee, 2006). Peers can be useful models, but interaction is more efficient when the model is an adult (Tudge & Wunterhoff, 1993).

In a classroom, collaborative work is one of the main factors in children's cultural development (Rieber & Carton, 1993). Students learn when they move from external (social) to internal (individual) and the teacher's role is to facilitate this transition (Rieber & Carton, 1987). They also learn through collaboration (Durlak et al., 2011), and this gives them a sense of belonging to a group as they establish social bonds (Cunnington, 2019). They learn by imitating behaviors, since imitation plays a vital social function. When students mirror what they see, they not only learn but also form social relationships (Gallese & Goldman, 1998; Iacoboni, 2009; Cunnington, 2019; Magister, 2024). Imitation activates the mirror neurons, and this activation is stronger when we see actions performed by people who belong to our social group (Magister, 2024). And the more we imitate others, the more connected we become (Iacoboni, 2009). This social form of human connection mirrors how trees form their canopies, both to avoid growing too close to their neighbors and to allow for the distribution of resources.

Though it hasn't been yet proved empirically, it is widely assumed that the mirror neuron system is the foundation of understanding not only the behavior and intentions of others, but also their experience (Lieberman, 2007). Emotions can ease or impede children's academic engagement (Durlak et al., 2011) so teachers should encourage them to believe in themselves (Bandura, 2001). Students learn social and emotional skills through exposure to appropriate behavior and social interactions (Iacoboni, 2009). According to Albert Bandura, observational learning helps us learn by watching others, not just through direct experience (Bandura, 2001). Action recognition and learning through observation are human innate abilities (Giudice et al., 2009). The stronger the empathy that forms between people, the greater the amount of imitation is (Iacoboni, 2009). Since the mirror neuron system is engaged during the experience of emotion, and this is the basis of empathy, we activate the same emotion in ourselves when we perceive it in others (Gallese et al., 2004; Jeon & Lee, 2018). When people show emotions such as happiness or anger, others feel their emotional state (Bandura, 1971). It is the mirror neuron system that becomes active and allows this emotional connection to form (Rizzolatti & Craighero, 2004).

Mirror neurons activate when we interact socially, helping us to learn by observation and imitation from those who have more experience (Magister, 2024). By imitating a behavior they see, children are more capable of performing intellectual tasks than they are on their own (Rieber, 1998). This development is possible because humans have the ability to learn by observing others' behavior (Giudice et al., 2009). Observational learning is an efficient strategy for adapting to changes in environmental conditions (Carcea & Froemke, 2019) and together with imitation and modelling it represents a way of learning (Koutroubas & Galanakis, 2022). This learning is different from any other form, due to our ability for social cognition (Tomasello et al., 1993). For Lev Vygotsky, imitation means understanding, and a person's ability to imitate is the basis for a zone of proximal development (Shabani et al., 2010) When teachers create a ZPD for their students they take into account the learners' primary and future learning (Rahman, 2024).

"The ZPD is an ever-changing distance between being and becoming." (Ness, 2022, p. 2). It represents expanding the possible and pushing the boundaries for what is known (Ness, 2022), since the human mind is constructed through our interactions with the world (Rahman, 2024). This space between what can be done alone and what can be achieved with assistance from someone who is more experienced represents the distance between independent skills and a child's actual mental age and his potential development (Ness, 2022; Rahman, 2024). The effectiveness of the ZPD depends on the quality of verbal interactions. It is established through collaboration with learners, because it stands for an opportunity for imitation (Shabani et al., 2010). And even if mirror neurons were discovered a few decades ago, Lev Vygotsky had already studied the process of development from a neurological perspective. The brain reorganizes neuronal connections and creates new systems (Vasileva & Balyasnikova, 2019). ZPD changes and evolves, as a result of multiple interactions. Teachers should not only offer assistance, but also challenge students within their ZPD (Rieber, 1998). In the teacher-student interaction, words are cultural tools. The teacher's role is to maintain this interaction (Vasileva & Balyasnikova, 2019), by creating an appropriate learning environment, and to provide structural help. Moreover, teachers should socially mediate learners to take control of their own learning. In order to foster student progress, teachers need to redefine educational goals (Shabani et al., 2010).

The ZPD involves creativity, play and emotions (Ness, 2022), as humans are biological creatures (Rodgers, 2015). When set in a positive environment, children let loose their imagination, and that helps them learn how to act in human relations and interactions (Ness, 2022). The way learning environments are organized can foster creativity (Marjonavic–Shane et al., in Ness, 2022) Moreover, the ZPD becomes stronger when teachers create a learning space defined by the sense of belonging to a group (Cunnington, 2019). Mirror neurons activate when we observe and imitate actions performed by people who belong to our social group (Magister, 2024). Every group is unique. Just like trees in a forest, classrooms create certain canopies, respecting each other's boundaries and needs. The forest management has lots of benefits from the phenomenon of crown shyness. Forest stability is increased, the biodiversity is conserved (Bhoi, 2024). And as Meg Lowman stated, trees distancing increases productivity (Wu, 2020). The same rules apply to classroom management, in terms of growth and development. The ZPD is mainly about social interaction and participatory learning, as it creates a collaborative learning environment (Ness, 2022).

Both the teacher and the student are active agents in children's learning (Rahman, 2024). A ZPD is created in the course of this social interaction, helping children acquire the ability to work independently (Tudge & Wunterhoff, 1993; Shabani et al., 2010). David L. Rogers states that learners need time to process what they learn, especially if the experience "was complex and designed to challenge." (Rodgers, 2015, p. 180). Likewise, Bandura states that fearful behavior can be overcome by observing others engage in the feared activities without any consequences (Bandura, 1971). Social learning is individual learning which is influenced by the social environment (Tomasello et al., 1993).

Lev Vygotsky believed that individual development cannot be conceived outside a social world (Tudge & Wunterhoff, 1993). In order for the scaffolding to be successful, the interaction teacher-learner is vital (Shabani et al., 2010). Their collaboration continues even when the teacher is not present anymore. For example, when the child solves a problem at home, following a model he observed at school (Rieber & Carton, 1987). According to Vygotsky, learners internalize the teacher's instructions and use them later to self-regulate (Tomasello et al., 1993).

In the ZPD, the learner's performance is mediated socially (Shabani et al., 2010). The role of the teacher, as the more knowledgeable one, is to tailor the best instruction in order to help the child reach the edge of his ZPD (Rieber & Carton, 1987). Teachers can foster a

positive working environment which makes students engage in learning (Cunnington, 2019). We are wired for empathy and emotions (Iacoboni, 2009), as well as supportive relations are vital for children's learning, since they will help children use their imagination (Ness, 2022). Most behaviors are learnt through the influence of example, because this learning eliminates the fear of making mistakes (Bandura, 1971). When socially interacting, students become more eager to engage and to enhance learning (De Felice, 2022) and the quality of their learning depends on the degree of their believing in what they can achieve (Bandura, 1977).

In order for a modelling learning to take place, the learners must pay attention and remember the behavior they have observed. By rehearsing and reinforcing it, learners create new patterns of behavior (Bandura, 1971). Motivation plays a vital role in the modelling process, as students demonstrate what they have learnt (Nabavi & Bijandi, 2012). Learning results in collaboration, where neither participant is an authority (Tomasello et al., 1993). Though past research was focused on learning in isolation, the students alone or the teacher, ignoring social interaction, we should consider learning as an inherent trait of our human nature (De Felice, 2022). We usually fear situations that we perceive as threatening or exceeding our abilities, so we avoid them. Students often get involved in activities they consider reassuring enough to be handled (Bandura, 1977). Teachers should create positive working environments where students are encouraged to overcome their fears and to get involved. If there is a malfunction in the mirror neuron system, learning from other people is deficient (Magister, 2024). Deficiencies and fears are interdependent, and when we avoid performing stressful activities, we interfere with the development of new skills (Bandura, 1977). Students acquire skills, knowledge and behaviors by observational learning (Magister, 2024), because learning doesn't occur only through direct experience, but also by imitation (Tudge & Wunterhoff, 1993; Magister, 2024).

Human learning occurs through vicarious experience: we observe the behavior of others, imitating it, and without the fear of making mistakes. This helps us to self-regulate and it increases the belief in our future ability (Bandura, 1971). It is by observing the actions of others that learners acquire more information with less risk (Tomasello, 2004). Our social minds help us anticipate others' feelings, thoughts, and actions, and our social interaction depends on our ability for social prediction (Tamir & Thornton, 2018). Vygotsky's theory of cognitive development refers to learning as a social process, whose main elements are the learner, the teacher, and their interaction (De Felice, 2022).

Learning plays a leading part in the psychological development of a child (Rieber & Carton, 1993). Their independent abilities are a reflection of a past development, and the way a child performs a task with guidance shows their future potential. The help received could be collaboration, imitation or scaffolding (Rieber, 1998). The term *scaffolding* was coined by Wood, Bruner and Ross in 1976 (Ness, 2022), but it was Vygotsky who first introduced the theoretical framework. For him, learners perform something in collaboration or with assistance, then they will perform it on their own (Shabani et al., 2010; Ness, 2022). Scaffolding is part of the ZPD, a process that supports students as they learn to perform a task independently (Rahman, 2024). Although there are few experimental studies in the impact scaffolding has during classes (Raslan, 2024), this supportive approach supports children to grow and to learn more (Ness, 2022), because they are not solitary thinkers anymore (Rahman, 2024). Similarly, crown shyness can be viewed as a hidden metaphor for self-regulation. Trees stop growing when they sense a specific frequency of light, known as far-red light (Dipanjan & Poulomi, 2018; Osterloff, 2020). Teachers offer support in the classroom, helping learners maximize their potential. Trees avoid overlapping, so that each tree has access to light, air and space. The idea of natural balance is reflected both in educational guidance and independence, and in the formation of crown shyness.

Scaffolding develops around the notion of ZPD and social-cultural of the mind (Shabani et al., 2010). It guides and helps the learner to do by himself tomorrow what he can only do assisted today (Rieber, 1998). In order to improve the ZPD progression, teachers should define goals during their teaching and learning (Rahman, 2024). There should always be a challenge added to these goals, as it creates a stronger interest in learning (Bandura, 2001).

Methodology

This study employs a qualitative, conceptual approach to explore the relationship between natural phenomena, such as crown shyness, mirror neurons and social learning theories. The research was identified by using search key terms such as "crown shyness", "mirror neurons", "Zone of Proximal Development", "Social Learning Theory". The databases consulted included Google Scholar, JSTOR, and ResearchGate. The research is based on an extensive literature review, drawing from foundational works by Lev Vygotsky and Albert Bandura, alongside recent studies on mirror neurons and social learning. Additionally, the metaphor of crown shyness in forest ecosystems is explored to illustrate the balance between individual autonomy and collective growth in the classroom.

Results and discussion

Learning is deeply rooted in social contexts. The conceptual analysis of this article provides relevant insights by linking natural metaphors to social learning theories and neurobiological mechanisms. The integration of metaphors such as crown shyness and mirror neurons gives a profound understanding of learning, blending biology, and cognition. We use our body to get a better adjustment with those around us during social interaction. Our mirror neurons activate helping us not only to read their minds, but also to predict their actions (De Felice, 2022). The same natural mechanism occurs in the forest. Trees tailor their canopy when sensing neighboring trees in order to avoid overlapping canopies, creating a form of social distancing (Baillargeion, 2020; Wu, 2020; Das, 2023) and they send signals to the nearby trees about resources (Bhoi, 2024).

A central result is the symbolic parallel between crown shyness and classroom dynamics. In forests, trees create structured spaces between their canopies, so as to avoid being too close to their neighbors (Dipanjan & Poulomi, 2018; Osterloff, 2020). Similarly, in a well-balanced classroom, students respect each other's social and cognitive space, fostering a safe environment for both independence and collaboration. Another key result lies in the role of mirror neurons as a bridge between observation, imitation, and learning. These cells support Bandura's theory that people learn by watching and imitating others. This imitation is connected to understanding and cooperation with adults or peers (Rieber, 1998). When students interact, the mirror neuron system amplifies empathy, motivation, and understanding.

Moreover, Vygotsky's Zone of Proximal Development (ZPD) provides a new meaning when viewed through the lens of crown shyness. Just as trees stop growing when they sense a specific frequency of light or feel the proximity of other trees, learners advance within a space that allows guidance without intrusion. Scaffolding, in this context, becomes the educational equivalent of the forest's natural calibration—encouraging growth without overwhelming the learner.

Conclusions

Our mirror neurons system activates when we observe and imitate actions performed by those who belong to our social group (Magister, 2024). Similarly, just like trees tailor their canopies to form green islands that work together, respecting boundaries and still promoting growth, for the benefit of all the ecosystems in the forest, human learning fosters social cohesion and collaborative growth.

Students collaborate and grow in a classroom where they respect each other's boundaries adjusting their behaviors to foster both independent thinking and group cohesion, just as trees form their canopies to avoid crowding one another, and to contribute to the welfare of the forest. Crown shyness is more common between trees of similar height (Putz et al., 1984), the same as classes respect the students' age. The social boundaries in the classroom are a reflection of the arboreal limitations trees naturally create when shaping the forest ecosystems. The metaphor of the crown shyness in the classroom learning process is about balance, fostering both individual autonomy and social connection.

Much like a forest where each tree grows in its own space yet contributes to the ecosystem, the classroom thrives when each student can grow independently, having both the freedom to explore, and the support to navigate safely. We may not yet fully understand the invisible thread that connects us all, whether in forests or within our own social groups, allowing us to be and to become. But from the shyness of the trees to the boldness of the humans, everything remains an interconnected metaphor, creating a balanced environment, where everyone can flourish.

References

Anderson, M. (2015). *Social-Emotional Learning and Academics: Better Together.* https://www.ascd.org/el/articles/social-emotional-learning-and-academics-better-together

Baillargeion, Z. (2020). *Trees Have Their Own Way of Social Distancing*. https://www.atlasobscura.com/articles/how-trees-social-distance

Bandura, A. (1971). *Social Learning Theory*, Stanford University. https://www.asecib.ase.ro/ mps/Bandura_SocialLearningTheory.pdf

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioral Change. *Psychological Review, 34*(2), 191-215. https://educational-innovation.sydney.edu.au/news/pdfs/ Bandura%201977.pdf

Bandura, A. (2001). Social Cognitive Theory: An Agentic Perspective. *Annual Review of Psychology, 52*, 1-26. https://ssrlsig.org/wp-content/uploads/2018/01/bandura-2001-social-cognitive-theory-an-agentic-perspective.pdf

Bastiaansen, J.A.C.J., Thioux, M., & Keysers, C. (2009). Evidence for mirror systems in emotion. *Philosophical Transactions of the Royal Society B, 364*, 2391-2404. http://doi.org/10.1098/rstb.2009.0058

Bhoi, C. (2024). Unveiling the canopy mystique: A comprehensive review of plant crown shyness. *International Journal of Botany Studies, 9*(10), 34-36. https://www.botanyjournals.com/assets/archives/2024/vol9issue10/9112.pdf

Blakeslee, S. (2006). Cells that read minds. https://www.researchgate.net/ publication/ 36709897_Cells_that_read_minds

Bratianu, C. (2022). *Knowledge strategies.* Cambridge University Press, Cambridge.

Bratianu, C., & Bejinaru, R. (2023). From knowledge to wisdom: Looking beyond the knowledge hierarchy. Knowledge, 3(2), 196-214. https://doi.org/10.3390/knowledge/3020014.

Bratianu, C., & Lefter, V. (2001). *Management strategic universitar*. RAO, Bucharest.

Carcea, I., Froemke, R.F. (2019). Biological Mechanisms for Observational Learning. *Curr Opin Neurobiol., 54*, 178-185. https://doi.org/10.1016/j.conb.2018.11.008

Catmur, C., Walsh, V., & Heyes C. (2009). Associative sequence learning: the role of experience in the development of imitation and the mirror system. *Philosophical Transactions of the Royal Society B, 364*, 2369-2380. http://doi.org/10.1098/rstb.2009.0048

Catmur, C., Press, C., & Heyes, C. (2016). Mirror Neurons from Associative Learning. In R.

Murphy, & R. Honey (Eds.). *The Wiley Handbook on the Cognitive Neuroscience of Learning* *WILEY-BLACKWELL*. https://kclpure.kcl.ac.uk/ws/portalfiles/portal/56051255/CatmurPressHeyes_CogNeuroLearning.pdf

Cunnington, R. (2019). Imitation, associative learning, and mirror neurons. https://solportal.ibe-unesco.org/articles/imitation-associative-learning-and-mirror-neurons/

Das, G. K. (2023). Social Distancing of Trees and Other Tree-Facts for Avoiding Diseases. *Indian Science Cruiser, 37(*3), 9-10. https://www.researchgate.net/publication/377778082_Social_Distancing_of_Trees_and_Other_Tree-Facts_for_Avoiding_Diseases#fullTextFileContent

De Felice, S., de C. Hamilton, A.F., Ponari, M., & Vigliocco G. (2022). Learning from others is good, with other is better: the role of social interaction in human acquisition of new knowledge. *Philosophical Transactions of the Royal Society B, 378*, 1-12. http://doi.org/10.1098/rstb.2021.0357

Das, G. K. (2023). Social Distancing of Trees and Other Tree-Facts for Avoiding Diseases. *Indian Science Cruiser, 37(*3), 9-10. https://www.researchgate.net/publication/377778082_Social_Distancing_of_Trees_and_Other_Tree-Facts_for_Avoiding_Diseases#fullTextFileContent

Dipanjan G., Poulomi D. (2018). Crown Shyness – A Fascinating Treetop Trend. *NIScPR Online Periodicals Repository, 55*, 46-47. https://sciencereporter.niscpr.res.in/

Durlak, J.A., Dymnicki, A., Weissberg, R.P., & Schellinger, K. (2011). *The* Impact of Enhancing Students' Social and Emotional Learning: A Meta-Analysis of School-Based Universal Interventions. *Child development, 82*(1), 405-432. https://doi.org/10.1111/j.1467-8624.2010.01564.x

Fini, C., Era, V., Da Rold, F., Candidi, M., & Borghi, AM. (2021). Abstract concepts in Interaction: The need of others when guessing abstract concepts smooths dyadic motor interactions. *Royal Society Open Science, 8*, 1-12. https://doi.org/10.1098/rsos.201205

Gallese, V., Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in cognitive sciences, 2*(12), 493-501. https://doi.org/10.1016/S1364-6613(98)01262-5

Gallese, V., Keysers, C., Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences, 8*(9), 396-403. DOI: 10.1016/j.tics.2004.07.002

Giudice, M.D., Keysers, C., & Manera, V. (2009). Programmed to learn? The ontogeny of mirror neurons._*Developmental Science, 12*(2), 350-363. DOI: 10.1111/j.1467-7687.2008.00783.x

Goudie J. W., Polsson, K. R., & Ott, P. K. (2009). An empirical model of crown shyness for lodgepole pine (Pinus contorta var. latifolia [Engl.] Critch.) In British Colombia. *Forest Ecology and Managemnet, 257*, 321-331. DOI: 10.1016/j.foreco.2008.09.005

Heyes, C. (2010a). Mesmerizing mirror neurons. *NeuroImage, 51*(2), 789-791. https://doi.org/10.1016/j.neuroimage.2010.02.034

Heyes, C. (2010b). Where do mirror neurons come from? *Neuroscience and Biobehavioral Reviews, 34,* 575-583. DOI: 10.1016/j.neubiorev.2009.11.007

Iacoboni, M. (2009). Imitation, Empathy and Mirror Neurons. *Annual Review of Psychology, 60*, 653-670. DOI: 10.1146/annurev.psych.60.110707.163604

Jeon, H., Lee, S.-H. (2018). From Neurons to Social Beings: Short Review of the Mirror Neuron System Research and Its Socio-Psychological and Psychiatric Implications. *Clinical Psychopharmacology and Neuroscience, 16*(1), 18-31. https://doi.org/10.9758/cpn.2018.16.1.18

Kilner, J.M., Lemon, R.N. (2013). What We Know Currently about Mirror Neurons. *Current biology, 23*(23), 1057-1062. doi: 10.1016/j.cub.2013.10.051

Koutroubas, V., Galanakis, M. (2022). Bandura's Social Learning Theory and Its Importance in the Organizational Psychology Context. *Psychology Research, 12*(6),

315-322. DOI: 10.17265/2159-5542/2022.06.001

Lakoff, G., Johnson, M. (1980). *Metaphors we live by*. The University of Chicago Press.

Lieberman, M.D. (2007). Social Cognitive Neuroscience: A Review of Core Processes. *Annual Review of Psychology, 58*, 259-289. DOI: 10.1146/annurev.psych.58.110405.085654

Magister, V.B. (2024). Mirrors of Learning: How Mirror Neurons Shape our Ability to Learn. *Acta Scientific Neurology, 7*(4), 25-38. https://actascientific.com/ASNE/pdf/ASNE-07-0723.pdf

Moffett, M. W. (2000). What's "Up"? A Critical Look at the Basic Terms of Canopy Biology. *Biotropica, 32*(4a), 569-596. https://doi.org/10.1111/j.1744-7429.2000.tb00506.x

Nabavi, R.T., Bijandi, M.S. (2012). Bandura's Social Learning Theory & Social Cognitive Learning Theory. *University of Science and Culture,* 1-24. https://mlsu.ac.in/econtents/ 4556_BandurasTheory.pdf

Ness, I. J. (2022). Zone of Proximal Development. In Glăveanu, V.P. (eds) *The Palgrave Encyclopedia of the Possible*, Palgrave Macmillan. DOI: https://doi.org/10.1007/978-3-030-90913-0_60

Osterloff, E. (2020). *Crown shyness: are trees social distancing too?* https://www.nhm.ac.uk/discover/crown-shyness-are-trees-social-distancing.html

Owens, M.T., Tanner, K.D. (2017). Teaching as Brain Changing: Exploring Connections Between Neuroscience and Innovative Teaching. *CBE-Life Sciences Education 16*(2), 1-9. doi: 10.1187/cbe.17-01-0005

Pellegrino, G., Fogassi, L., Fadiga, L., & Gallese, V. (1992). Understanding motor event: A neurophysiological study. *Experimental Brain Research, 91*, 176-180. DOI: 10.1007/BF00230027

Putz, F. E., Parker, G. G., Archibald, R. M. (1984). Mechanical Abrasion and Intercrown Spacing. *The American Midland Naturalist, 112*(1), 24-28. https://doi.org/10.2307/2425452

Rahman, L. (2024). Vygotsky's Zone of Proximal Development of Teaching and Learning. In STEM Education. *International Journal of Engineering & Technology, 13*(8), 1-7. https://www.researchgate.net/publication/383400353_Vygotsky's_Zone_of_Proximal_Development_of_Teaching_and_Learning_in_STEM_Education

Ramachandran, V. (2009). The neurons that shaped civilization. https://www.ted.com/talks/vilayanur_ramachandran_the_neurons_that_shaped_civilization

Ramachandran, V. (2022). Mirror Neurons and Imitation Learning as the Driving Force Behind the Great Leap Forward in Human Evolution. https://www.edge.org/conversation/_vilayanur_ramachandran-mirror-neurons-and-imitation-learning-as-the-driving-force

Raslan, G. (2024). The Impact of the Zone of Proximal Development Concept (Scaffolding) on the Students Problem Solving Skills and Learning Outcomes. In Al Marri, K., Mir, F.A., David, S.A., Al-Emran, M. (eds) BUiD Doctoral Research Conference 2023. *Lecture Notes in Civil Engineering, vol 473.* Springer, Cham. https://doi.org/10.1007/978-3-031-56121-4_6

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research, 3,* 131-141. DOI: 10.1016/0926-6410(95)00038-0

Rizzolatti, G., Craighero, L. (2004). The Mirror-Neuron System. *Annual review of Neuroscience, 27*, 169-192. https://doi.org/10.1146/annurev.neuro.27.070203.144230

Rizzolatti, G., Craighero, L. (2006). Mirror neuron: A neurological approach to empathy. *Research and Perspectives in Neuroscience*, 107-123. https://doi.org/10.1007/3-540-29803-7_9

Rodgers, D.L. (2015). The Biological Basis of Learning. *Simulation & Gaming, 46*(2), 175-186. DOI:10.1177/1046878115590585

Shabani, K., Khatib, M., & Ebadi, S. (2010). Vygotsky's Zone of Proximal Development: Instructional Implications and Teachers' Professional Development. *English Language Teaching, 3*(4), 237-248. https://files.eric.ed.gov/fulltext/EJ1081990.pdf

Snyder, A.N. (2019). Mirror Neurons and Their Effect on Social-Emotional Learning. *Medford Public Schools*. https://medfordccsr.org/wp-content/uploads/2019/02/Mirror-Neurons-SEL-3.pdf

Tamir, D.I., Thornton, M.A. (2018). Modeling the predictive social mind. *Trends Cogn Sci., 22*(3), 201-212. https://doi.org/10.1016/j.tics.2017.12.005

Thursd (2025). The Mysterious Yet Fascinating Phenomenon of Crown Shyness. https://thursd.com/articles/tree-crown-shyness

Tomasello, M., Kruger, A.C., & Ratner, H.H. (1993). Cultural Learning. *Behavioral and Brain Sciences, 16*, 495-552. https://doi.org/10.1017/S0140525X0003123X

Tomasello, M. (2004). Learning Through Others. *Daedalus, 133*(1), 51-58. DOI:10.1162/001152604772746693

Tudge, J.R.H., Wunterhoff, P.A. (1993). Vygotsky, Piaget, and Bandura: Perspectives on the Relations between the Social World and Cognitive Development. *Human Development, 36*, 61-81. DOI:10.1159/000277297

Van der Zee, J., Lau, A, & Shenkin, A. (2021). Understanding crown shyness from a 3-D perspective*. Annals of Botany XX,* 1-11. DOI: 10.1093/aob/mcab035

Vasileva, O., Balyasnikova, N. (2019). (Re)Introducing Vygotsky's Thought: From Historical Overview of Contemporary Psychology. *Front. Psychol, 10-1515,* 1-15. https://doi.org/10.3389/fpsyg.2019.01515

Vygotsky, L. S., Rieber, R. W., & Carton, A. S. (Eds.) (1993). *The collected works of L. S. Vygotsky: The fundamentals of defectology (abnormal psychology and learning disabilities).* (J. E. Knox & C. B. Stevens, Trans. Plenum Press.

Vygotsky, L. S., Rieber, R. W., & Carton, A. S. (Eds.) (1997). *The Collected Works of L.S. Vygotsky, Volume 1, Problems of General Psychology.* (J. E. Knox & C. B. Stevens, Trans. Plenum Press.

Vygotsky, L. S., Rieber, R. W. (Ed.) (1998). *The Collected Works of L.S.Vygotsky, Volume 5, Child Psychology.* (J. E. Knox & C. B. Stevens, Trans. Plenum Press.

Wu, K. J. (2020). Some trees may 'social distance' to avoid disease. https://www.nationalgeographic.com/science/article/tree-crown-shyness-forest-canopy.