Why do we teach?

Nicola Pensiero

nicola.pensiero@unimore.it

Abstract

The ubiquity of teaching in human societies poses a significant puzzle, particularly when considering that much of modern education involves abstract concepts, which do not directly enhance survival. This paper reviews two main perspectives on the origins of teaching: teaching as a cognitive adaptation for transmitting complex knowledge, and teaching as a cultural product of modern societies. The evidence indicates that teaching is present in all societies, suggesting it may be an evolutionary adaptation. However, skills including complex ones can be learned through other forms of social learning such as imitation. This paper proposes a third perspective: teaching as a by-product of our proclivity to cooperate. By examining ethnographic studies, psychology experiments, and surveys on teachers' motivations, this paper argues that teaching requires traits like mind reading, communication, and altruism, which are foundational for cooperation. Teaching reflects our social nature, not just a mechanism for knowledge transmission. This reframing has important implications for educational theory and practice, particularly in how we conceptualise the aims of schooling, design curricula, and balance the goals of autonomy, citizenship, and labour market preparation

Introduction

The widespread presence of teaching across human societies presents a compelling yet debated puzzle. The reasons behind its ubiquity are contested due to disagreements over its definition and the interpretation of empirical evidence of its incidence across cultures

(Csibra and Gergely 2011, Lancy 2016, Lew-Levy et al. 2020, Strauss and Ziv 2012, Fray and Gore 2018).

While teaching is widespread, much of what modern educational institutions impart involves abstract concepts, which do not directly enhance survival and thus cannot be explained as an adaptive behaviour rooted in biological selection. Learning such abstract theories necessitates teaching, even though historical survival did not depend on knowing them. The prevalence and perceived significance of teaching suggest biological foundations and universality. However, educational institutions are modern creations absent in small-scale cultures like hunter-gatherer societies.

This enigma has sparked debate between two main perspectives: one posits teaching as a cognitive adaptation primarily for transmitting complex knowledge (Caro & Hauser, Hoppitt et al. 2008, Kruger and Tomasello 1996, 1992 Strauss et al. 2014; Ziv and Frye 2004,). This perspective argues that teaching transmits information and procedures more effectively than unassisted, firsthand learning (Premack and Premack 1996). Teaching is seen as a high-fidelity but costly mode of knowledge transmission specifically suited for complex information.

In contrast, the cultural perspective views teaching as a recent invention of modern, affluent Western societies, with limited presence in hunter-gatherer societies and an arguable necessity for learning essential skills (Lancy 2010a, Lancy 2010b, Lancy and Grove 2010, Rogoff 2003, 2011). Except for a few outliers (Boulter 2017, Frølund 2016, Misawa 2014), both philosophers and education scholars fundamentally view education as a socio-cultural process, yet they disagree on its purpose: some see it mainly as transmitting knowledge, while others emphasize nurturing individual autonomy; some focus on equipping students for work and citizenship, whereas others prioritize their personal growth and transformation; and some consider its role to be preserving existing class structures, while others believe it should foster social change (Boulter 2017). Boulter (2017) argues that adopting a biological perspective enables us to move beyond this dichotomy by offering a coherent perspective on the significance of education and curriculum which does not involve political commitments. This paper aligns with Boulter's project (2017) and seek to offer a more integrative perspective on the evolutionary,

biological and societal significance of teaching. Specifically, it applies the comparative method from biology — examining traits and behaviours across different societies and species — to assess two dominant perspectives: teaching as a cultural product and as cognitive adaptation. Combining insights from multiple disciplines, it will review evidence from surveys on teachers, anthropological and ethnographic studies on teaching in horticultural and hunter gatherer societies, psychology experiments against those two main perspectives revealing that both have shortcomings. The evidence shows that all societies, including hunter gather ones, use teaching, which would suggest that teaching is a cognitive adaptation (for reviews see Garfield et al. 2016, Kruger and Tomasello 1996). However, there is no direct relationship between the complexity of the knowledge learnt and the type of learning. Teaching occurs across different areas of knowledge and is not exclusive to complex domains, with other types of social learning such as imitation and observation regularly used for learning complex skills (Hewlett and Roulette 2016, Lew-Levy et al. 2017). Finally, it will argue that a third perspective, hardly acknowledged, should be considered: teaching is a by-product of adaptations in other domains and particularly of our proclivity to cooperate and be social. The evolutionary perspective advanced in this paper offers important insights into the nature of teaching and has significant implications for educational practice.

Teaching as a cultural product

While philosophers and education researchers generally regard education as a cultural product, anthropologists studying small-scale societies are divided between those who see education as culturally constructed and those who interpret it as an adaptive trait. Some cultural anthropologists argue that teaching is a feature of modern industrial societies and that in small scale societies has a marginal role (Lancy 2010a, Lancy 2010b, Lancy and Grove 2010, Rogoff 2003, 2011) or is an "unnecessary interference" even (Lancy 2010a, p. 82). Following Kline (2015), this definition of teaching can be characterized as culture based. Compared to the modern industrial societies, where learning occurs in formal settings, in small scale cultures, learning occurs mostly informally by observing and imitating others with little role for 'student-centred, developmentally appropriate

instruction by dedicated adults' (Lancy 2010a, p. 97), typical of Western schools (Rogoff 2003, 2011). According to the cultural anthropology approach children are self-starters and learn mostly through independent exploration or observation without the authoritarian intervention of adults. Learning is thought to be a social process that goes form the bottom to the top rather the other way around and learners take advantage of the social environment to replicate the observed behaviours practiced by more expert members of her community (Lancy 2016, Bloch et al. 2001).

The analysis of teaching typical of this approach emphasizes the conscious top-down transmission of knowledge as the criteria to distinguish teaching from behaviour that facilitates learning in others. For teaching to occur, Lancy (2016) argues that the behaviour that facilitates learning in others is intended to teach and does not serve some other purpose(s), that the behaviour is ubiquitous among humans and essential to their survival, and that teaching is unlikely when the knowledge or skill can be acquired in easier ways than teaching, as teaching is generally costly to the teacher (Lancy 2016). As a corollary, teaching should exclude cases of knowledge acquisition where learning occurs as a secondary effect of an activity which would have taken place in any case and is not facilitated in any way by the adult's behaviour. Those cases can be called assisted learning. Examples of situations where learning occurs socially but not through teaching are children observing an adult crafting an object with the adult being aware of the learning possibilities that the experience might provide. Or parents that provide their child with a toy tool kit, with the primary purpose of keeping the child entertained. In both cases learning is a secondary effect of another activity, there is no conscious transmission of knowledge, yet novices acquire knowledge through interacting with adults. Using this approach, Lancy, in his review of 1500 published and unpublished reports, concludes that children learn complex skills without Western-based approaches to education and teaching is rare in hunter gatherer and small-scale societies (Lancy 2014).

The previous approach to defining teaching has the advantage of using specific criteria, yet its core theoretical premises are questionable. First, the criterion that teaching must impart essential survival skills to be considered evolutionarily significant is problematic because not all evolutionarily significant behaviours are adaptive (Laland et al. 2008,

West-Eberhard 2003). While evolutionarily significant abilities are universal among individuals of a species, many traits are both universal and evolutionarily significant without being adaptive. Instead, they may be linked to other adaptive behaviours. If evidence suggests that essential skills are not primarily transmitted through teaching, this does not imply that teaching lacks evolutionary significance. Teaching may be universally present not as an adaptive trait but as a by-product of another trait. For instance, language is a universal trait with various functions, some of which are not directly adaptive. Its primary function is as an instrument of thought, yet it is universally used for speech and communication, which are secondary functions of thought and language (Berwick and Chomsky 2016).

Second, the proposed distinction between evolutionary significant abilities and cultural ones is dubious. The former, such as hunting, would be naturally developed by interacting with the natural environment, while the latter, such as mathematics, are learnt in a top-down process typical of formal education because children lack the natural ability to acquire them on their own (Geary 2007, Lancy 2016). Contrary to this view, recent research shows that the very type of ability it is used an example of cultural ability – arithmetic – is innate. Children as young as five months demonstrate the ability to count and make decisions that involve counting (Wynn et al. 2002). In general, any ability including those which are not adaptive such as higher order mathematical knowledge build on an adaptive, evolutionary significant ability, which limits and scopes the higher order ability (Butterworth 2010, Dehaene 2011).

The insistence on the adaptive nature as a criterion to define the evolutionary significance of teaching is not convincing and accounts also for the empirical conclusion about the rarity of teaching in pre-industrial societies. According to this approach, survival and evolutionary significant skills are not transmitted through teaching, which implies that teaching is marginal and rare in pre-industrial societies. Indeed, not all social–cultural anthropologists agree with the conclusion that teaching is a modern invention. Garfield et al. (2016), and Kruger and Tomasello (1996) used the definitions of teaching from cognitive psychology discussed below and indeed find multiple examples of teaching in their cross-cultural surveys of learning in humans.

In addition to the conceptual issues, the scan observational methods used by anthropologists despite providing rich account of learning do not systematically observe and classify children' activities so they often miss subtle and brief teaching events. The next section discusses examples of studies that use systematic observation to capture teaching episodes.

The emphasis on independent exploration and observation free from authoritarian adult intervention resonates with critical theories of education that view schools primarily as instruments to maintain the current structure of power relations. From this perspective, education systems function as mechanisms for selecting and reproducing traits that align with the demands of hierarchical, often authoritarian workplaces: authority resides with the teacher, compliance is expected from students, and behavioural regulation is enforced through rule-based reward and punishment systems (Bernstein 1971, Bowles and Gintis 1976). This structure prioritises obedience and rule-following often at the expenses of creativity and independent thinking.Traits such as obedience, perseverance, an internal locus of control, and disciplined self-consciousness are not only cultivated within schools but also closely correspond to those rewarded in the labour market.

This alignment between the hierarchical structure in schools and the labour relations within the workplace – articulated by the correspondence principle (Bowles and Gintis 1976) - highlights a tension between competing educational philosophies. Progressive approaches advocate for schooling that nurtures independent thinking, creativity, and exploration, whereas more conservative views emphasise the role of education in inculcating social norms and preparing youth for economic productivity. In the discussion section, I argue that while the critique of authoritarian pedagogy is important, it is incomplete. I will then introduce the revised version of the correspondence principle that addresses these limitations.

Teaching as a cognitive adaptation

Teaching, when viewed as a cognitive adaptation, contrasts sharply with the culture-based definition of teaching, which often limits it to the formal, school-based education

characteristic of Western societies. Functionalist and mentalistic approaches, however, align with the cognitive adaptation hypothesis as outlined by Kline (2015). The functionalist approach explores teaching across species, identifying it in situations where a more knowledgeable individual alters its behaviour to guide learners through progressively challenging levels of competence, addressing the learners' evolving needs. This process often incurs a cost to the teacher, who does not derive immediate benefits from the act of teaching (Caro and Hauser 1992, Hoppitt et al., 2008). On the other hand, the mentalistic approach shifts focus from observable behaviours to the mental processes involved in teaching, defining it as a deliberate effort to facilitate knowledge acquisition in a less knowledgeable individual (Kruger and Tomasello 1996, Strauss et al., 2014, Ziv and Frye 2004,). Teaching, in this view, is an intentional activity aimed at increasing another individual's knowledge, relying on the theory of mind—the ability of both teacher and learner to understand the intentions of others.

Previously, I introduced cultural anthropology’s critique of the cognitive adaptation hypothesis, which argues that teaching is rare in small-scale societies and therefore unlikely to be an adaptive behaviour. This conclusion partly stems from the application of a Western definition of teaching and partly from the use of data collection methods based on ethnographic observation, self-reports, and interviews. The brevity of many teaching episodes and the issues associated with self-reporting suggest that such studies may have underreported teaching occurrences. A more effective approach would be to systematically record children's behaviour and interactions over extended periods. Indeed, few studies have systematically analysed teaching in small-scale hunter-gatherer societies (Boyette and Hewlett 2017, Hewlett and Roulette 2016, Kline et al. 2013, Lew-Levy et al. 2020, Maynard 2002).

These studies employ a functionalist definition of teaching, demonstrating that it is consistently utilized in hunter-gatherer cultures. For instance, Hewlett and Roulette (2016) videotaped 12- to 14-month-old Aka children during their daily interactions and found that teaching was frequent, taking various forms such as natural pedagogy, demonstration, task assignment, providing learning opportunities, and feedback provision. They observed approximately 10 teaching events per hour, typically brief, often

lasting only a few seconds. These teaching instances were used to convey both social norms and survival skills, such as digging for roots, cutting food, building houses, or climbing trees. Interestingly, they found that the Aka community, which values autonomy and minimally intervenes in children's learning, displayed a relatively high frequency of teaching events during infancy. Teachers' intimate knowledge of learners likely accounts for the brevity of these teaching episodes.

Further research by Lew-Levy et al. (2020) observed 35 Hadza children and 38 BaYaka children for two 2-hour time blocks over a single day, using a 30-second observe/30-second record procedure. Their findings revealed that 14% of Hadza children's time and 11% of BaYaka children's time was devoted to teaching or being taught subsistence skills, with child-to-child teaching occurring more frequently than adult-child teaching. Boyette and Hewlett (2017) studied children aged seven to twelve from eight Aka communities and three Ngandu neighborhoods, observing them across three two-hour periods over three days. They found that teaching occurred at least once during the observation period for the majority of children, although it was less frequent compared to observational learning. These children received and provided teaching, often from parents and other adults.

Garfield et al. (2016) conducted a systematic review using the electronic Human Relations Area Files (eHRAF) database, analyzing social learning in 23 hunter-gatherer cultures worldwide. Employing a behavior-based definition of teaching, they found that teaching was the most commonly described method of transmission in ethnographic texts, followed by observation and imitation. This review challenges the notion that teaching is a cultural product of Western societies and rarely occurs in hunter-gatherer societies, a conclusion drawn by Lancy (2014).

When examining nonindustrial societies more broadly, Kruger and Tomasello (1996) conducted a systematic analysis of teaching across different cultures, including hunter-gatherer societies. Using a definition of teaching based on intentions and mind reading, they concluded that all cultures have some form of teaching. The evidence presented above suggests that teaching exists across various cultures, including hunter-gatherer ones, supporting the hypothesis that teaching is an inherent part of human nature and,

therefore, evolutionarily significant. This leads us to further explore the role of teaching in the evolution of adaptive capacities.

The discussion above showed that teaching exists across different cultures including hunter-gather ones. This provides support for the hypothesis that teaching is part of our nature, in other terms is evolutionary significant. We now take a step further in analysing the role of teaching in relation to the evolution of adaptive capacities.

The hypothesis that teaching is a cognitively adaptive ability presupposes those certain skills, essential for survival and reproduction, are best acquired through teaching. Since teaching requires more investment than other forms of learning, it is expected to be employed primarily for skills that are difficult to acquire through other means and not for those that can be learned more easily through methods such as observation. However, research shows that teaching is not limited to transmitting complex skills and knowledge, as the hypothesis would suggest, but also includes basic skills that could be easily learned through observation. Conversely, complex skills are often acquired through non-teaching-based learning methods (Lew-Levy et al. 2017, Hewlett and Roulette 2016). This lack of a clear relationship between the complexity of skills and teaching as the primary mode of transmission indicates that learning across different domains occurs through various means, without a consistent correlation between the type of learning and the complexity of the skills learned.

According to the cognitive adaptation approach, learners are also expected to be selective when choosing a teacher, opting to acquire knowledge from the most competent individual and using cues of success as a proxy for teaching quality. However, research on hunter-gatherer societies shows that key competencies, such as hunting skills, are transmitted without the selection of teachers based on such cues. Adolescents often nominate any accessible adult as a teacher, regardless of success indicators, age, or body mass, learning within a broad and open network of adult teachers (Lew-Levy et al. 2021).

Another implication of teaching as a cognitively adaptive behaviour is that it should predominantly occur between biologically related individuals since it is a costly and selfless activity in which the teacher facilitates learning without immediate direct benefits

(Caro and Hauser 1992). Studies on hunter-gatherer societies reveal that young individuals learn subsistence skills mainly from their mothers and biologically related adults, but they also acquire specialized hunting skills and social norms from both related and unrelated community members.

A central tenet of the hypothesis that teaching is a cognitive adaptation is the idea that humans have a natural ability to teach, which manifests from an early age (Strauss, 2005, 2013; Strauss & Ziv, 2012; Strauss et al., 2002, 2014). Despite its complexity, how to teach is learned reflexively without instruction, thus suggesting that teaching is a natural ability (Strauss 2005). Children, who are not taught how to teach, are able to teach how to play games and perform tasks such as dancing and building constructions with blocks (Ziv and Frye 2004). Children tend to teach when they recognise a knowledge gap in the recipient (Maynard 2002, Strauss and Ziv, 2012, Ziv et al. 2008, Ziv and Frye 2004). Children as young as age 3 teach effortlessly and spontaneously using demonstrations. Five year old children accompany demonstrations with explanations, feedback behaviours and errors diagnosis (Strauss, Ziv and Stein 2002). Teaching occurs effortlessly and without teachers being aware of the cognitive principles underlying their approaches and techniques. Teachers can explain the reason underlying what they did when teaching - for example, breaking up complex material into simpler components to help pupils to learn (Steiner 2002, Strauss and Shilony 1994) - however, they cannot clearly explain the cognitive principles underlying the complexity reduction.

This view suggests that small children possess a theory of mind—a prerequisite for teaching—which enables them to infer others' beliefs and intentions, compare them to their own knowledge, and draw conclusions about the validity of those beliefs (Adolphs 2003, Brothers 1990;). This ability is crucial for social interactions and develops early in life (Behne et al. 2005, Kovács et al. 2010). Its impairment is associated with conditions such as autism (Frith 1994) and schizophrenia (Brüne 2005). Autism, for instance, illustrates the severe impact of lacking a theory of mind, with devastating consequences on socialization, communication, and imagination (Baron-Cohen 1999).

By nine months, children can infer others' intentions and predict their actions based on goals (Behne et al. 2005). By age one, they refine their mind-reading capabilities

(Liszkowski et al. 2008, Schoeppner, Sodian and Pauen 2006, Rochat, Striano and Morgan 2004), and by age four, they develop a full theory of mind (Flavell 2004, Wellman, Cross, and Watson 2001). Evidence of theory of mind development comes from various sources, often assessed through 'false belief task' experiments. In these experiments, children are shown scenarios where another person—say, John—places an object in a cupboard and leaves the scene. In John's absence, the object is moved to a different location, such as a basket. Children who have not yet developed a theory of mind typically predict that John will search for the object in the basket, failing to recognize that John cannot know its new location. In contrast, children with a developed theory of mind correctly infer John's false belief and predict that he will search in the cupboard. Liszkowski et al. (2008) conducted an experiment with 12-month-old preverbal children, where the experimenter accidentally knocks an object off a table in one situation, pretends to look for it, and asks the infant where it is. In another situation, the experimenter knows the object's location but still asks the infant where it is. In the first scenario, infants point to the object's location; in the second, few infants point to its location, demonstrating that infants use a theory of mind to recognize when there is a knowledge gap between themselves and the experimenter.

Paleo-Archaeological records of activities that require a theory of mind date back to 30000-40000 years ago: around that time, there are the first representations of impossible entities - the half-man-half lion ivory statuette from Hohlenstein-Stadel, southern Germany, and the painting of the half-man-half-reindeer, from Trois-Freres, Ariege, in France (Baron-Cohen 1999). These are fictious representations of entities that exist only in imagination and pretence, hence they couldn't be created without a theory of mind. From the period, evidence from burial rituals show that humans adorned dead individuals with jewellery. For example, in Sungir, Russia, around 30000 YO a 60- year-old man was buried with two younger individuals and all three were decorated with thousands of ivory beads, necklaces, and bracelets. This evidence suggests that the decorator cared about how others perceive the dead persons and wanted an audience to think the persons were beautiful and of high status. All this evidence suggests from at least 30- to 40000 years ago, our ancestors had a theory of mind (Baron-Cohen 1999).

Contrary to the theory that teaching is a natural ability, the natural pedagogy theory instead argues that teaching does not require a theory of mind. Teachers use naturally ostensive communication, such as raising eyebrows, talking in motherese, eye contact, directing speech to the infant and calling the infant by its name, which learners have a predisposition to detect (Csibra and Gergely 2009). Natural pedagogy transmits naïf learners relevant knowledge more efficiently in opaque contexts thanks to demonstration by any adults accompanied by ostensive signals. Natural pedagogy is independent from and evolved before mindreading and language capacities when tools started being used by early hominids more than 2 million years ago. Tools had multiple and complex uses which are cognitively opaque to understand and made learning from imitation difficult. Natural pedagogy theory argues that this difficulty in learning may have led to the unique human teaching system that allows the transmission of opaque and complex knowledge.

The natural pedagogy's claim that teaching occurs through ostensive signals provided by a more experienced demonstrator is not supported by empirical research. In contexts with opaque or conflicting information, children choose the type of information to acquire based on evidence and the prestige of the teacher, not just its intention and signals, suggesting that young learners are selective in choosing what to learn and from whom contrary to what we might expect based on natural pedagogy (Harris and Corriveau 2011, Heyes 2016, Sobel and Kushnir 2013).

Moreover, learning complex knowledge including complex tools does not require teaching and ostensive signals. Learning through ostensive signals is an important natural ability, but it is one of the many components of teaching and learning (Kline 2015). At the same time, ostensive signals have a generic function as signals of trustworthiness, which individuals use to decide who to associate with for a variety of experiences including learning, safety and political alliances. In the next section, I discuss the idea that the ability to use ostensive signals and to teach in general is a consequence of an adaptation developed to function as a social agent.

Social scientists and philosophers have traditionally viewed the distinctive nature of education as a socially constructed phenomenon, often resisting the notion that it might

also be an evolved, adaptive behaviour. Because formal education is unique to humans, it is frequently taken as evidence of Homo sapiens' capacity to transcend biological determinism through cultural innovation. Boulter (2017), however, offers a compelling philosophical argument that education may be both uniquely human and biologically adaptive. He suggests that evolution has endowed our species with the capacity to acquire culturally mediated knowledge and skills necessary for securing resources, whereas most other animals rely predominantly on innate behaviours for survival.

This paper builds on and extends Boulter's thesis by advancing a biologically grounded view of education. It begins by recognising two key points. First, not all higher-order cognitive abilities in humans are necessarily adaptive. Second, while the propensity to teach may be a stable feature of our species, it may not have evolved specifically for the purpose of transmitting knowledge. Teaching could instead be a by-product of other prosocial or cooperative traits.

The abrupt emergence of abstract, creative and symbolic thought starting around 300,000 years ago further challenges adaptationist accounts. The lag between the appearance of new cognitive capacities in early Homo species and their eventual technological or cultural applications suggests that not all innovations were shaped directly by natural selection (Pääbo 2014). Evolutionary change in the genus Homo often follows a pattern of long periods of stasis followed by sudden leaps. For instance, the development of hand axes occurred well after the emergence of Homo ergaster, indicating that novel traits can arise before their eventual function is realised (Pääbo 2014).

Finally, although humans are prolific social learners, teaching is only one of several modes of cultural transmission. Its function may not be reducible to knowledge transfer alone. Once we acknowledge that not all biological traits are adaptations selected for their most common use, we can explore alternative hypotheses about the nature of teaching—beyond both the cultural constructivist and the transmission-based views. These possibilities will be examined in the following section.

Teaching as a by-product of our social inclinations

In what follows I present the argument that our mind reading ability (theory of mind) and ostensive communication developed to interact in a compassionate and cooperative way with other conspecifics, and teaching might have benefited from those traits. In contrast to the cognitive adaptation hypothesis, this argument views education as a by-product of other traits rather than an adaptation in itself. Education would thus belong to the category of traits that, while universal across members of a species and evolutionarily significant, are not directly adaptive. Teaching, in particular, may be universally present not because it was selected for independently, but as an emergent outcome of our broader prosocial dispositions. The ability to infer others' beliefs and intentions is a precondition for the evolution of cooperation (Herrmann et a. 2007, Muthukrishna and Henrich 2016). Humans evolved in groups with complex interactions, which provided the evolutionary pressure to develop the ability to identify potential co-operators and defectors (Wrangham 2019, Gintis 2017, Bøggild and Petersen 2016). Our species is characterised by selflessness, other regarding preference, fairness, altruism, eagerness to share food and information and cooperate even with non-relatives. Despite cooperation is often the most desirable strategy for the group, defecting or free riding is even more successful for the individual. To establish a cooperative equilibrium within the group, humans had to counteract defecting tendencies and punish / ostracize defectors (Gallier 2016, Gil de Zúñiga et al. 2017, Nowak and Sigmund 2005, van Apeldoorn and Schram 2016). During the long period in which humans evolved without accumulating wealth, they developed antihierarchical attitudes. The teaching for cooperation hypothesis is that the emergence of other regarding preferences and cooperative attitudes in our species accounts for our species-specific (uniquely human) ability to teach.

The ability to detect deception and cheating cues was key to these processes (Trivers 1971). The cheater-detecting mechanism is universal and probably natural. Indeed, hunter-horticulturalists are as good at cheating detection as individuals from developed countries (Sugiyama et al. 2002). Social intelligence and the theory of mind might have

evolved to detect cheating tendencies and curb defecting strategies. The literature on evolutionary game theory shows the strong relationship between the ability to infer mental states of others and group cooperative equilibria. In strategic laboratory games, individuals manifest their intentions to trust and reciprocate using happy facial expressions (Eckel and Wilson 2003, Scharlemann et al. 2001). In the prisoner's dilemma and public good experiments a substantial portion of individuals play the cooperative strategy and in repeated games they respond to defection by defecting, and to cooperation by cooperating. Humans might have developed psychological mechanisms including the theory of mind (Trivers 1971) and communication through ostensive signals to curb cheating and establish cooperation within the group. Indeed, the brain areas activated during games involving cooperative exchange overlap with the areas activated by activities induced to test the theory of mind tasks (McCabe et al. 2001, Rilling et al. 2004).

The hypothesis that teaching is ingrained in our cooperative tendencies finds support in its social nature: teachers often have no biological relationship to their learners (Hewlett and Roulette 2016); furthermore, teaching extends beyond skills that can be learned through observation and imitation (Hewlett and Roulette 2016, Lew-Levy et al. 2017), and it is provided regardless of immediate personal gain or collective benefits, exemplified by systematic instruction even for those with learning challenges. In essence, teaching is a costly activity not easily justified by the nature of the knowledge imparted or kinship alone. This suggests it stems from a propensity to altruistically share knowledge, with social benefits that transcend mere learning outcomes.

This view aligns closely with Vygotsky’s sociocultural theory, which places social interaction at the centre of learning (Vygotsky 1978). According to Vygotsky, cognitive development occurs through guided participation in culturally meaningful activities, often mediated by more knowledgeable others. His concept of the Zone of Proximal Development (ZPD) captures the essence of teaching as a cooperative act: learners accomplish more with help than alone (Vygotsky 1978). This suggests that teaching is grounded in trust, responsiveness, and shared intentionality.

The timing of the development of the theory of mind, language and cooperative attitudes offers a crucial insight into the nature of abilities that make teaching possible. The sudden emerge of complex tools and symbolic creations coinciding with the appearance of homo sapiens suggests that language, abstract and creative thinking including mind reading emerged at once and rapidly around 300.000 years ago with homo sapiens (Berwick and Chomsky 2016, Wrangham 2019). On the other hand, our cooperative attitude emerged earlier and evolved throughout a longer period. Language and thinking emerged in a brief period and therefore were not subject to selection (Berwick and Chomsky 2016), whilst our cooperative attitudes evolved through selection and independently from our ability to think and use language, although the ability to communicate, once emerged, facilitated the expression of intentions, thus accelerating the evolution of cooperation. The best explanation of the evolution of our cooperative tendencies is that they are a by-product of the self-domestication that humans undertook (Wrangham 2019). Domestication in other animals occurs through the human-led selection of the paedomorphic capacity for reduced aggression, more tolerance, greater cooperation and social learning. In humans, domestication did not occur by interacting with other species, but emerged as a secondary consequence of evolutionary selection against reactive aggression, which makes less aggressive, more social and cooperative individuals more likely to survive and pass their genes onto the next generation.

The different evolutionary paces of our cooperative and political attitudes and our ability to think creatively suggest that those traits have emerged independently from each other. It also suggests that teaching hinges on traits which developed for other purposes and independently from each other.

Surveys about teachers' motivation to enter and stay in the profession provide support to the hypothesis of the cooperative and altruistic character of teaching (for a review Fray and Gore 2018). Studies generally identify three types of motivations to be a teacher - intrinsic, altruistic and extrinsic (Fray and Gore 2018). Intrinsic motivation includes the enjoyment of the subject matter, but this alone does not justify choosing teaching over other professions that offer similar intrinsic satisfaction with better rewards. Extrinsic motivations pertain to the advantages of being a teacher, such as job stability and a good

work-life balance. These factors are more significant in the developing world than in the Western world, where teaching often lacks material advantages compared to other professions. Altruistic reasons, i.e. the desire to contribute in an important way to the socialisation and development of the youth, play an important role in deciding whether to become and remain a teacher (Fray and Gore 2018).

Discussion

The analysis of the nature of teaching carries important implications for contemporary education systems. First, as discussed, social learning is a multifaceted process that includes not only direct instruction from a more experienced member of society to a less experienced one, but also learning through imitation and observation. Recognising teaching as just one mode within this broader repertoire of social learning highlights the need to give greater prominence to peer-based learning processes. One particularly effective form of social learning is peer collaborative learning. Numerous studies have consistently demonstrated its effectiveness, both in enhancing academic performance consistently with Collaborative Cognitive Load Theory (CCLT, Kirschner et al., 2018),and in promoting social integration (Slavin 1996, Johnson and Johnson 2009).. . CCLT (Kirschner et al. 2018) theorises that, under the right conditions, peer collaboration improves learning outcomes by distributing cognitive load among learners. However, CCLT also cautions that for collaboration to be beneficial at the individual level, tasks must be sufficiently complex to justify the additional time and effort required for coordination and communication. While CCLT offers evidence for the efficiency gains from peer-based learning, this article roots such a collaboration in evolved social dispositions like shared intentionality, mind reading, and altruism. Peer-based learning is therefore not only effective but also a reflection of our cooperative nature. Notably, peer-based learning is especially conducive to the transmission of cumulative knowledge. There is no straightforward relationship between task complexity and the incidence of teaching across species: even cognitively sophisticated animals rarely teach, as most skills can be acquired through imitation or trial-and-error learning (Laland 2017). In contrast, teaching in humans is particularly effective for transmitting cumulative knowledge that otherwise

would be difficult to acquire. While modern education prioritises individual achievement and short-term assessment outcomes, human teaching historically functioned as a cooperative activity largely decoupled from formal evaluation or extrinsic incentives. Knowledge was shared collectively, often without direct personal gain, yet with transformative and unintended consequences: the accumulation of cultural knowledge across generations. This suggests that the focus of modern teaching on individual achievement and test performance is not only distant from, but potentially in tension with, the cooperative nature of teaching and its long-term cumulative benefits.

Importantly, collaborative learning does not only yield cognitive benefits. It also plays a critical role in reducing intercultural distance among students from diverse backgrounds (Johnson and Johnson 2009). By encouraging dialogue, mutual problem-solving, and shared tasks, peer learning fosters social bonds and challenges prejudice, an outcome that aligns closely with theories of teaching as a fundamentally social endeavour.

Second, the hypothesis that schools indoctrinate students into accepting the values of dominant social groups warrants critical reconsideration. The correspondence principle, as formulated by Bowles and Gintis, suggests that the structure and function of schooling reflect the hierarchical organization of the workplace, thereby preparing students for future labour roles. This interpretation presumes a rigid model of socialization in which students passively internalize dominant norms and values. However, such a view has been criticized for its neglect of human agency and for conceptualizing cultural learning as a black box. In response to these critiques, Bowles and Gintis (2002) developed a revised framework that avoids the “oversocialized” conception of the individual by drawing on insights from biology, specifically cultural evolution theory and replicator dynamics.

In this reformulation, cultural transmission is understood as dynamic and strategic. Students adopt, retain, or modify cultural traits based on the alignment between parental and educational models, as well as on the perceived payoffs of those traits. Children assess the relative advantages of traits modelled by parents or teachers, often using peers’ experiences as reference points. Traits associated with greater institutional rewards, such as high grades, are more likely to be adopted and disseminated, even if

they do not yield long-term benefits for all students. Moreover, the adoption of cultural traits is influenced by the heterogeneity of the student and teacher populations, particularly in terms of their conformity to prevailing social norms. Within any population, some individuals tend to align with existing behaviours endorsed by others, while others pursue novel or non-conforming patterns of behaviour. From this perspective, while schools may indeed facilitate the proliferation of traits advantageous to dominant groups (e.g., employers), they can also function as mechanisms of cultural change rather than mere instruments of social reproduction.

Third, several policy implications follow from the preceding analysis. Anthropological studies of hunter-gatherer societies show that education traditionally serves both to transmit practical skills and to instil social norms essential for group cohesion. In contrast, modern education systems prioritise labour market skills, often at the expense of citizenship education (Hoskins and Janmaat 2019). This imbalance is especially stark in vocational tracks, which tend to exclude subjects that foster political literacy, critical thinking, and civic engagement (Hoskins et al. 2012). To redress this, citizenship education should become a priority across all educational pathways. Bridging the gap between academic and vocational tracks – by integrating general subjects and civic education into vocational curricula – would affirm the equal political agency of all students. Such reforms would help re-establish education's broader role in preparing individuals not just as workers, but as active, informed citizens.

Anthropological evidence further indicates that, in hunter gatherer societies, children often have substantial autonomy over what, how, and from whom they learn and that teaching occurs through invitation, play, observation and active participation (Boyette and Hewlett 2017, Garfield et al. 2016, Hewlett and Roulette 2016, Lew-Levy et al. 2017). This evidence stands in contrast to the authoritarian structure of modern systems of education. International evidence indicates that disciplinary practices in contemporary schools often rely on control. While physical punishment remains legally permitted and practiced in many countries (Heekes et al. 2022), in Western education systems, non-physical forms of punishment – such as isolation, exclusion from activities, public reprimand, and withdrawal of privileges – are more prevalent and institutionalised

(Gregory et al. 2010). These practices are often grounded in behaviourist frameworks that emphasise rule compliance and punishment over autonomy or intrinsic motivation. Such systems contrast sharply with cooperative models of teaching grounded in intrinsic motivation, responsiveness, and trust.

From an evolutionary perspective, these disciplinary norms may hinder, rather than support, the development of the prosocial dispositions that underpin human teaching and learning. This contrast invites a reconsideration of how power and pedagogy are configured in schools, and whether current models foster or inhibit the full human potential of learners.

At a minimum education systems should move decisively away from punitive disciplinary practices, including non-physical ones. Instead, schools should foster environments where learners are active participants, not passive recipients. This includes involving students in setting classroom rules, co-designing learning goals, and participating in evaluation processes (Biesta 2011). Moreover, curricula should be designed to encourage independent exploration, curiosity, and hypothesis testing, rather than rigid content delivery aimed at standardised test performance. These practices are not only more aligned with the evolutionary roots of teaching as a cooperative activity, but are also supported by research linking student autonomy and participatory learning to higher levels of motivation, critical thinking, and long-term academic success (Reeve 2006, Zimmerman 2002).

Conclusions

The exploration of why humans teach, encompassing both biological and cultural perspectives, reveals a complex interplay of cognitive and social factors. This paper critically reviewed the primary hypotheses that teaching is either a cognitive adaptation specifically for transmitting complex knowledge (Caro and Hauser 1992, Hoppitt et al. 2008, Kruger and Tomasello 1996, Strauss et al. 2014, Ziv & Frye 2004) or a cultural product unique to modern, industrial societies (Lancy 2010a, Lancy 2010b, Lancy and Grove 2010, Rogoff 2003, 2011). Additionally, it introduced a third perspective that

considers teaching as a by-product of our broader evolutionary adaptations for sociality and cooperation.

The cognitive adaptation hypothesis posits that teaching evolved to solve adaptive problems, providing a high-fidelity method to transmit complex knowledge efficiently (Caro and Hauser 1992, Hoppitt et al. 2008, Kruger and Tomasello 1996, Strauss et al. 2014, Ziv & Frye 2004). This hypothesis is supported by the sophisticated theory of mind capabilities seen in humans from a young age (Adolphs 2003, Behne et al., 2005, Brothers 1990, Kovács et al. 2010). Studies of hunter-gatherer societies, often considered representative of early human social structures, show that teaching is prevalent even in these communities (for reviews see Garfield et al. 2016, Kruger and Tomasello 1996). This suggests that teaching is not exclusively a modern phenomenon but rather a fundamental aspect of human nature.

On the other hand, the cultural product hypothesis argues that the formal, top-down transmission of knowledge seen in modern educational institutions is a recent development, shaped by the demands of complex, industrial societies. In smaller-scale societies, learning often occurs through observation and imitation, with minimal direct instruction from adults (Lancy 2010a, Lancy 2010b, Lancy and Grove 2010, Rogoff 2003, 2011).

The paper proposes that teaching might be a by-product of other evolutionary adaptations, particularly those related to our proclivity for cooperation and sociality. Human societies are characterized by high levels of altruism, cooperation, and social learning, which are crucial for group survival (Bøggild and Petersen 2016, Gintis 2017, Herrmann et a. 2007, Muthukrishna and Henrich 2016, Wrangham 2019,). Teaching, in this context, can be seen as an extension of these social behaviours, facilitated by our advanced theory of mind and communication skills.

The development of theory of mind allows humans to understand and predict others' mental states, making teaching possible by recognizing the knowledge gaps in others and providing appropriate guidance. This capability, combined with our innate tendencies towards altruism and cooperation, suggests that teaching may have evolved not just to

transmit complex knowledge but as part of our broader social toolkit. Moreover, the motivations for teaching, as identified in surveys, often include altruistic reasons, emphasizing the desire to contribute to the socialization and development of others (Fray and Gore 2018). This supports the idea that teaching is intertwined with our social nature and cooperative behaviours.

The review draws on a wide range of evidence from anthropology, psychology and educational studies, highlighting the multifaceted nature of teaching. It shows that teaching exists across various cultures, including hunter-gatherer societies, where it plays a role in transmitting both practical skills and social norms.

While the evidence supports elements of both the cognitive adaptation and cultural product hypotheses, it also points to the need for a more nuanced understanding. Teaching appears to be a complex behaviour that likely evolved through multiple pathways, involving both direct selection for specific cognitive abilities and as a by-product of our social and cooperative nature.

It should be noted that whilst the teaching as adaptation and as by-product are presented as alternative theories for simplicity, it is possible that they are complementary. Teaching may have initially evolved as a cognitive adaptation for transmitting specific kinds of information, especially in opaque or high-stakes learning domains (e.g. tool use, social norms). Over time, it may have been exapted (repurposed) for more abstract knowledge such as calculus or different purposes such as cooperative interactions. Or vice versa, teaching may have emerged initially as a by-product of our social inclinations, then natural selection may have refined it for the purpose of cultural transmission.

In conclusion, teaching is a distinctive human behaviour that integrates cognitive, social, and cultural dimensions. Its prevalence across different societies and its roots in fundamental human traits such as cooperation and mind-reading suggest that it is a multifaceted adaptation.

Such an integrative view not only enriches our grasp of the significance of teaching but also opens up new avenues for educational practice. By appreciating the full spectrum of social learning – including imitation, observation, peer collaboration, and informal

guidance – educators can develop more diverse and effective teaching strategies that extend beyond traditional top-down instruction from teacher to student. This holistic approach acknowledges the diverse ways in which knowledge and skills are transmitted, ultimately fostering a more adaptive and responsive educational system.

References

Adolphs, R. (2003). Investigating the cognitive neuroscience of social behavior. Neuropsychologia, 41(2), 119-126.

Baron-Cohen, S. (1999). The evolution of a theory of mind. In M.C. Corballis, S.E.G. Lea (Eds.), The descent of mind: psychological perspectives on hominid evolution, Oxford University Press, Oxford (1999), pp. 261-277.

Behne, T., Carpenter, M., Call, J., & Tomasello, M. (2005). Unwilling versus unable: Infants' understanding of intentional action. Developmental Psychology, 41, 328–337.

Bernstein, B. (1971). Class, codes and control: Vol. 1. Theoretical studies towards a sociology of language. London: Routledge & Kegan Paul.

Berwick, R. C., & Chomsky, N. (2016). Why only us: Language and evolution. MIT press.

Biesta, G. J. (2011). *Learning democracy in school and society: Education, lifelong learning, and the politics of citizenship*. Springer Science & Business Media.

Bloch, M. E. F., Solomon, G. E.A., & Carey, S. (2001). Zafmaniry: An understanding of what is passed on from parents to children: A cross-cultural investigation. Journal of Cognition and Culture, 1, 43-68.

Bøggild, T., & Petersen, M. B. (2016). The evolved functions of procedural fairness: An adaptation for politics. The evolution of morality, 247-276.

Boyette, A. H., & Hewlett, B. S. (2017). Autonomy, equality, and teaching among Aka foragers and Ngandu farmers of the Congo Basin. Human Nature, 28(3), 289-322.

Boulter, S. (2017). Education from a biological point of view. *Studies in Philosophy and Education*, *36*, 167-182.

Bowles, S., & Gintis, H. (1976). *Schooling in capitalist America*: Educational Reform and the Contradictions of Economic Life. New York: Basic Books.

Bowles, S., & Gintis, H. (2002). Schooling in capitalist America revisited. *Sociology of education*, 1-18.

Brothers L. (1990). The social brain: a project for integrating primate behavior and neurophysiology in a new domain. Concepts Neurosci 1, 27-51.

Brüne, M. (2005). "Theory of mind" in schizophrenia: a review of the literature. Schizophrenia bulletin, 31(1), 21-42.

Butterworth, B. (2010). Foundational numerical capacities and the origins of dyscalculia. Trends in cognitive sciences, 14(12), 534-541.

Caro, T. M. & Hauser, M. D. (1992) Is there teaching in nonhuman animals? The Quarterly Review of Biology 67(2), 151–74.

Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1567), 1149-1157.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. Trends in cognitive sciences, 13(4), 148-153.

Dehaene, S. (2011). *The Number Sense: How the Mind Creates Mathematics*. Oxford University Press.

Eckel, C. C., & Wilson, R. K. (2003). The human face of game theory: Trust and reciprocity in sequential games. Trust and reciprocity: Interdisciplinary lessons from experimental research, 245-274.

Flavell, J. H. (2004). Theory of mind development: Retrospect and prospect. Merrill-Palmer-Quarterly, 50, 274–290.

Fray, L., & Gore, J. (2018). Why people choose teaching: A scoping review of empirical studies, 2007–2016. Teaching and Teacher Education, 75, 153-163.

Frith, U. (1994). Autism and theory of mind in everyday life. Social development, 3(2), 108-124.

Frølund, S. (2016). Naturalness as an educational value. *Journal of Philosophy of Education*, *50*(4), 655-668.

Gallier, C. (2020). Democracy and compliance in public goods games. European Economic Review, 121, 103346.

Garfield, Z., Garfield, M., & Hewlett, B. S. (2016). A cross-cultural analysis of hunter-gatherer social learning. In H. Terashima & B. S. Hewlett (Eds.), Social learning and innovation in contemporary hunter-gatherers: Evolutionary and ethnographic perspectives (pp. 19–34). Tokyo: Springer Japan.

Geary, D. C. (2007). Educating the evolved mind. In Jerry S. Carlson & Joel R. Levin (Eds.), Educating the evolved mind (pp. 1-99). Charlotte, NC: Information Age Publishing.

Gergely, G., & Csibra, G. (2006). Sylvia's receipe: the role of imitation and pedagogy in the transmission of human culture. In N. J. Enfield & S. C. Levenson (Eds.), Roots of human sociality: Culture, cognition and human interaction (pp. 229–255). Oxford: Berg Publishers.

Gil de Zúñiga, H., Diehl, T., & Ardévol-Abreu, A. (2017). Internal, external, and government political efficacy: Effects on news use, discussion, and political participation. Journal of Broadcasting & Electronic Media, 61(3), 574-596.

Gregory, A., Clawson, K., Davis, A., & Gerewitz, J. (2016). The promise of restorative practices to transform teacher-student relationships and achieve equity in school discipline. *Journal of Educational and Psychological Consultation*, *26*(4), 325-353.

Harris, P. L., & Corriveau, K. H. (2011). Young children's selective trust in informants. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1567), 1179-1187.

Heekes, S. L., Kruger, C. B., Lester, S. N., & Ward, C. L. (2022). A systematic review of corporal punishment in schools: Global prevalence and correlates. *Trauma, Violence, & Abuse*, *23*(1), 52-72.

Heyes, C. (2016). Who knows? Metacognitive social learning strategies. *Trends in Cognitive Sciences*, 20(3), 204-213.

Herrmann, E., Call, J., Hernández-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. science, 317(5843), 1360-1366.

Hewlett, B. S., & Roulette, C. J. (2016). Teaching in hunter–gatherer infancy. Royal Society Open Science, 3(1), 150403.

Hoppitt, W. J., Brown, G. R., Kendal, R., Rendell, L., Thornton, A., Webster, M. M., & Laland, K. N. (2008). Lessons from animal teaching. Trends in ecology & evolution, 23(9), 486-493.

Hoskins, B., & Janmaat, J. G. (2019). *Education, democracy and inequality*. Palgrave Macmillan UK.

Hoskins, B., Janmaat, J. G., & Villalba, E. (2012). Learning citizenship through social participation outside and inside school: An international, multilevel study of young people's learning of citizenship. *British educational research journal*, *38*(3), 419-446.

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational researcher*, *38*(5), 365-379.

Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano R, J. (2018). From cognitive load theory to collaborative cognitive load theory. *International journal of computer-supported collaborative learning*, *13*(2), 213-233.

Kline, M. A., Boyd, R., & Henrich, J. (2013). Teaching and the life history of cultural transmission in Fijian villages. Human Nature, 24(4), 351-374.

Kline, M. A. (2015). How to learn about teaching: An evolutionary framework for the study of teaching behavior in humans and other animals. Behavioral and Brain sciences, 38, e31.

Kovács, Á. M., Téglás, E., & Endress, A. D. (2010). The social sense: Susceptibility to others' beliefs in human infants and adults. Science, 330(6012), 1830-1834.

Kruger, A. C., & Tomasello, M. (1996). Cultural learning and learning culture. In D. Olson & N. Torrance (Eds.), The handbook of human development and education (pp. 369–387). Oxford: Blackwell.

Laland, K. N. (2017). *Darwin's unfinished symphony: How culture made the human mind*. Princeton University Press.

Laland, K. N., Odling-Smee, J., & Gilbert, S. F. (2008). EvoDevo and niche construction: building bridges. Journal of Experimental Zoology Part B: Molecular and Developmental Evolution, 310(7), 549-566.

Lancy, D. F. (2010a). Learning 'from nobody': The limited role of teaching in folk models of children's development. Childhood in the Past, 3(1), 79-106.

Lancy, D. F. (2010b). When nurture becomes nature: Ethnocentrism in studies of human development. Behavioral and Brain Sciences, 33(2), 99.

Lancy, D. F., & Grove, M. A. (2010). The role of adults in children's learning. In The anthropology of learning in childhood (eds DF Lancy, J Bock, S Gaskins), pp. 145–180. Lanham, MD: AltaMira Press.

Lancy, D. F. (2014). The anthropology of childhood: Cherubs, chattel, changelings, Second ed. Cambridge: Cambridge University Press.

Lancy, D. F. (2016). Teaching: natural or cultural? In D. Berch & D. Geary (Eds.), Evolutionary perspectives on education and child development (pp. 33–65). Heidelberg: Springer.

Lew-Levy, S., Reckin, R., Lavi, N., Cristóbal-Azkarate, J., & Ellis-Davies, K. (2017). How do hunter-gatherer children learn subsistence skills? A meta-ethnographic review. Human Nature, 28, 367-394.

Lew-Levy, S., Kissler, S. M., Boyette, A. H., Crittenden, A. N., Mabulla, I. A., & Hewlett, B. S. (2020). Who teaches children to forage? Exploring the primacy of child-to-child teaching among Hadza and BaYaka hunter-gatherers of Tanzania and Congo. Evolution and Human Behavior, 41(1), 12-22.

Lew-Levy, S., Milks, A., Kiabiya Ntamboudila, F., Broesch, T., & Kline, M. A. (2021). BaYaka adolescent boys nominate accessible adult men as preferred spear hunting models. Current Anthropology, 62(5), 631-640.

Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. Cognition, 108(3), 732-739.

Maynard, A. E. (2002). Cultural teaching: the development of teaching skills in Maya sibling interactions. Child Development, 73(3), 969–982.

McCabe, K., Houser, D., Ryan, L., Smith, V., & Trouard, T. (2001). A functional imaging study of cooperation in two-person reciprocal exchange. Proceedings of the national academy of sciences, 98(20), 11832-11835.

Misawa, K. (2014). Nature, Nurture, Second Nature: Broadening the horizons of the philosophy of education. *Educational Philosophy and Theory*, *46*(5), 499-511.

Muthukrishna, M., & Henrich, J. (2016). Innovation in the collective brain. Philosophical Transactions of the Royal Society B: Biological Sciences, 371(1690), 20150192.

Nowak, M. A., & Sigmund, K. (2005). Evolution of indirect reciprocity. Nature, 437(7063), 1291-1298.

Pääbo, S. (2014). The human condition—a molecular approach. *Cell*, *157*(1), 216-226.

Premack, D. & Premack, A. J. 1996. Why animals lack pedagogy and some cultures have more of it than others. In: Handbook of Education and Human Development: New Models of Learning, Teaching and Schooling (Ed. by D. R. Olson & N. Torrance), pp. 302e323. Oxford: Blackwell.

Raihani, N. & Ridley, A. R. (2008). Experimental evidence for teaching in wild pied babblers. Animal Behaviour 75(1):3–11.

Rochat, P., Striano, T., & Morgan, R. (2004). Who is doing what to whom? Young infants' developing sense of social causality in animated displays. Perception, 33, 355–369.

Schoeppner, B., Sodian, B., & Pauen, S. (2006). Encoding action roles in meaningful social interaction in the first year of life. Infancy, 9, 289–311.

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The elementary school journal*, *106*(3), 225-236.

Rilling, J. K., Sanfey, A. G., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2004). The neural correlates of theory of mind within interpersonal interactions. Neuroimage, 22(4), 1694-1703.

Rogoff, B. (2003). The cultural nature of human development. Oxford university press.

Rogoff, B. (2011). Childhood and learning: how do children learn without being taught. One way is by observing and pitching in. Anthropology of Children and Youth Interest Group Newsletter, 8.

Sobel, D. M., & Kushnir, T. (2013). Knowledge matters: How children evaluate the reliability of testimony as a process of rational inference. *Psychological Review*, 120(4), 779-797.

Scharlemann, J. P., Eckel, C. C., Kacelnik, A., & Wilson, R. K. (2001). The value of a smile: Game theory with a human face. Journal of Economic Psychology, 22(5), 617-640.

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary educational psychology*, *21*(1), 43-69.

Sugiyama, L. S., Tooby, J., & Cosmides, L. (2002). Cross-cultural evidence of cognitive adaptations for social exchange among the Shiwiar of Ecuadorian Amazonia. Proceedings of the National Academy of Sciences, 99(17), 11537-11542.

Steiner, J. (2002). English teachers' on-action mental models of their pupils' learning. Ph.D. dissertation, School of Education, Tel Aviv University.

Strauss, S. (2005). Teaching as a natural cognitive ability: Implications for classroom practice and teacher education. In D. Pillemer & S. White (Eds.), Developmental psychology and social change (pp. 368–388). New York, NY: Cambridge University Press.

Strauss, S. (2013). A call for a multidisciplinary approach to the scientific study of teaching: Inspirations from Howard Gardner. In: Mind, work, and life: A Festschrift on the occasion

of Howard Gardner's 70th birthday, with an introduction and comments by Howard Gardner (Vol. 2), ed. M. Kornhaber & E. Winner, pp. 474–94. The Offices of Howard Gardner.

Strauss, S., Calero, C. I., & Sigman, M. (2014). Teaching, naturally. Trends in neuroscience and education, 3(2), 38-43.

Strauss, S., & Shilony, T. (1994). Teachers' models of children's minds and learning. In L. Hirschfeld & S. Gelman (Eds.), Mapping the mind: Domain-specificity in cognition and culture (pp. 455–473). Cambridge, UK: Cambridge University Press.

Strauss, S., & Ziv, M. (2012). Teaching is a natural cognitive ability for humans. Mind, Brain, and Education, 6(4), 186–196.

Strauss, S., Ziv, M., & Stein, A. (2002). Teaching as a natural cognition and its relations to preschoolers' developing theory of mind. Cognitive Development, 17, 1473–1787.

Thornton, A., & Raihani, N. J. (2008). The evolution of teaching. Animal behaviour, 75(6), 1823-1836.

Thornton, A. & McAuliffe, K. (2006) Teaching in wild meerkats. Science, 313(5784), 227–29.

Trivers, R. L. (1971). The evolution of reciprocal altruism. The Quarterly review of biology, 46(1), 35-57.

van Apeldoorn, J., & Schram, A. (2016). Indirect reciprocity; a field experiment. PloS one, 11(4), e0152076.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (Vol. 86). Harvard university press.

Wellman, H. M., Cross, D., & Watson, J. (2001). A meta-analysis of theory of mind development: The truth about false belief. Child Development, 72, 655–684.

West-Eberhard, M. J. (2003). Developmental plasticity and evolution. Oxford University Press.

Wrangham, R. (2019). The Goodness Paradox: The Strange Relationship Between Virtue and Violence in Human Evolution. New York: Vintage.

Wynn, K., Bloom, P., & Chiang, W. C. (2002). Enumeration of collective entities by 5-month-old infants. Cognition, 83(3), B55-B62.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into practice*, *41*(2), 64-70.

Ziv, M., & Frye, D. (2004). Children's understanding of teaching: The role of knowledge and belief. Cognitive Development, 19, 457–477.

Ziv, M., Solomon, A., & Frye, D. (2008). Young children's recognition of the intentionality of teaching. Child Development, 79, 1237–1256.