A Review of Teaching in Human and Nonhuman Animals

by

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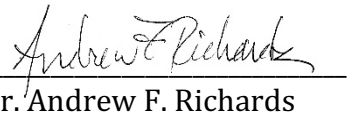

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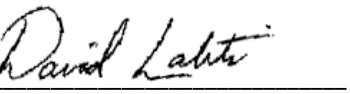

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Abstract

Teaching has long been thought to be unique to humans. However, there is increasing evidence that some nonhumans engage in teaching. This paper reviews teaching in nonhumans and humans. All known examples of teaching in nonhumans are based on nepotism. Nepotistic teaching is also universal in humans. However, at some point in human evolution teaching has expanded and has acquired a strong reciprocity component as well. Teaching in human hunter-gatherer societies is proposed as a model for teaching earlier in human evolution. Building upon the review of teaching here, this paper provides some speculation of how human teaching evolved into a reciprocity-based system and it uses this perspective to discuss current issues in the United States teaching system.

Introduction

Teaching has become a widespread occupation in modern human societies, and young humans (and their parents) in such societies rely on formal teaching to give them a way to navigate their environment, both non-socially and socially, to be successful. This state of affairs is often taken for granted, but teaching as a paid occupation, and teaching of children by non-relatives is unlikely to be the way humans originally evolved to learn and to teach. Members of many nonhuman species also acquire skills and information from others, but until relatively recently it was thought that nonhumans did not teach. The information transfer of nonhumans was thought to be the result of social learning mechanisms in the observer, and that skilled individuals did not adjust their behavior to facilitate learning in a potential pupil (Danchin et al., 2004). However, in the last two

decades, several examples of teaching in nonhumans have been established, but the number of examples is small, and the taxonomic distribution is diverse. In particular, teaching has not been unambiguously demonstrated where it might be most expected – in large brained, social species such as our closest relatives the two species of chimpanzee, the many dolphin species, nor the two elephant species (Whiten, 2017; Bates et al., 2010). Although one case of elephant teaching has been suggested, the observations have multiple possible interpretations (Bates et al., 2010). Nevertheless, the known examples of nonhuman teaching do allow some speculative conclusions as to when and how such abilities evolve (Hoppitt et al., 2008; Thornton and Raihani, 2008) – including when teaching might not evolve even if some of the underlying capabilities have evolved.

These hypotheses about the evolutionary origins of teaching in nonhumans may also provide some insight into why and how humans evolved into the very capable students and teachers that we are. In addition, a consideration of the possible kinds of ways that teachers could benefit from teaching is important. There is a strong likelihood that teaching in humans started out similar to other animals in that teachers originally benefitted entirely through the enhanced success of their students because students were always relatives. However, unlike other animals, at some point in human history many kinds of human teaching became directed towards non-relatives. General hypotheses about kinds of cooperation and their evolutionary origins (Hamilton, 1964; Trivers, 1971; Alexander, 1987) can be used to hypothesize about the transition of humans from an original teaching practice probably more like nonhumans, one based on nepotism, to the present widespread form of teaching in which adult teachers teach non-relatives (mostly young) for pay and social status, i.e. reciprocity based teaching.

The goals of this paper are the following: (1) provide a review of the relevant literature on teaching in nonhumans and humans, (2) discuss the evolution of teaching in humans, and lastly, (3) reflect on and provide recommendations for the current teaching system in the United States.

Definitions

This paper adopts the following definitions. *Learning* refers to the acquisition of new information, skills or behaviors through experience. Learning can take place either *individually* or *socially*. In the case of *individual learning* the animal acquires the new information or behavior as a result of their own experiences, where they are either rewarded or punished based on their actions. For example, in *individual learning*, a child touches a flame for the first time and learns that being burned by fire is extremely painful. Therefore, they will not touch it again in the future. On the other hand, in *social learning* the individual gains information by observing another animal's interactions with the environment or conspecifics (Galef, 1995). For example, juvenile black rats copy adult black rats in stripping pinecones to access seeds (Terkel, 1996). It is important to note that while the juvenile rat is learning by observing a peer that this is not an example of teaching.

Teaching can be defined as an instructional method where the teacher modifies its behavior only in the presence of the student without receiving an immediate benefit for itself. The teacher's behavior either encourages or punishes the student's behavior or provides the student with an experience, resulting in the student acquiring knowledge or a skill (Caro and Hauser, 1992). Presumably the modification of the teacher's behavior has some cost to the teacher – perhaps in time and energy spent that could have been directed

toward other more profitable goals, or increased exposure to danger. All learning through teaching is a form of social learning, but much social learning does not involve teaching. According to Byrne and Rapaport (2011), "in order for teaching to occur there must be a two-way communication so that the teacher can adjust their behavior or strategy to meet the needs of the student". In the case of the black rat example, the adult rat does not modify its behavior in the presence of the juvenile. Since the adult's behavior is not modified and the adult rat does not encourage or punish the juvenile's behavior, the exchange can clearly be defined as social learning only, without a teaching component.

Cooperation is defined by Dugatkin (1997) as a joint action for mutual benefit. Sachs et al. (2004) take a more one-sided view and note that cooperation really has to be analyzed by assessing the costs and benefits of a cooperative act separately for each party in the cooperation. The Sachs et al. (2004) definition is more explicit about the fact that some kinds of cooperation involve a cost to one of the cooperators during the cooperative act - a cost that must somehow become a net benefit for the interaction to be a true cooperation. Some cooperation is mutually beneficial and benefits both parties simultaneously, but there remain several categories of cooperation in which one party benefits, but the main cooperator takes on a cost. The central question for these kinds of cooperation is how does the cooperator, who took on a cost, eventually benefit. Teaching, as defined above, therefore involves cooperation under either definition. The student is presumed to benefit from the teaching. The open question in any instance of teaching is how the teacher benefits from the teaching. Because teachers modify their behavior at some presumed cost to themselves (a direct cost or an opportunity cost or both), the

cooperation between teacher and student has to be analyzed in a way that can account for how the teacher benefits from their own modified behavior.

There are four main forms of cooperation, three of which assume costs to one of the cooperators and are therefore relevant to teaching. These three kinds of cooperation are the candidates for identifying how teachers benefit. The first form of cooperation is the form in which both parties benefit simultaneously and is best termed byproduct mutualism (Sachs et al., 2004). A second form of cooperation, and the first in which a cost is taken on, is cooperation with relatives (Hamilton, 1964; Sachs et al., 2004) also known as nepotism (Alexander, 1987). A third form of cooperation, and the second in which a cost is taken on, is *reciprocity* (or reciprocal altruism), in which costly aid given by one animal to another would be reciprocated, i.e., paid back, later in time (Sachs et al., 2004). Trivers (1971) introduced the concept of reciprocity and outlined the necessary criteria: (1) a large benefit to the recipient and small cost to the donor, (2) opportunities for cooperative interaction, and (3) the ability to detect cheaters. Reciprocity is very common in humans and mostly taken for granted by humans (although, as emphasized by Trivers, humans are very sensitive to many kinds of cheating). Reciprocity may be rare in nonhumans. Although Trivers proposed several examples of reciprocity in nonhumans, none of those examples have stood up to scrutiny. The best proposed example of reciprocity in non-humans comes from the sharing of blood meals in vampire bats. Wilkinson (1984) and Carter and Wilkinson (2013) reported that when vampire bats return to their roosts after successful foraging trips, they sometimes regurgitate food (blood) for hungry nest mates. They found food sharing was most often directed both to kin and unrelated individuals that had a history of sharing food with the donor. This example also demonstrates n*epotism* (or kin

selection): cooperation which involves helping kin (Hamilton, 1964). A fourth form of cooperation is an elaboration of the third form. *Indirect reciprocity* occurs when support is given by a third party to individuals (the second party) who have helped others (the first party) at a cost to the second party (Alexander, 1987). Indirect reciprocity occurs commonly in humans and has not been demonstrated in any nonhuman although it has been suggested. The importance of indirect reciprocity is that it leads to public evaluation of potential reciprocity partners, and the emergence of reputation and status as highly important additional benefits to cooperators.

The above definitions will be discussed in more detail in the following sections.

Teaching in Nonhumans

There are many examples of teaching that occurs naturally in nonhuman animals. All of the following cases satisfy the Caro and Hauser (1992) criteria for identifying teaching. There are other examples that do not meet all three criteria – (1) teacher modifies behavior in presence of student, (2) teacher incurs a cost but receives no immediate benefit, (3) student learns something new from the interaction – but are definitely candidates for teaching in nonhuman animals. However, those cases are considered outside the scope of this paper. In all of the following cases, the teacher modifies their behavior in the presence of the learner in order to impart knowledge.

Domestic chickens have been shown to teach their chicks on how to differentiate between profitable and nonprofitable food items (Nicol, 2006). In order to model appropriate feeding behaviors, a mother hen will call her young to the food using food calls and pecking the food items on the ground. The hens will give more intense and longer food

calls when a high-quality food is present. The mother hens then observe their young and modify their strategies in response to their chicks. If the chick begins feeding on unpalatable food, the mother hen increases her rate of food pecking, food dropping and food scratching to call her young's attention to the appropriate food choice.

Cheetahs, which are naturally solitary hunters, modify their feeding behaviors to teach their young how to hunt for food. Cheetah mothers bring either dead or injured prey to their offspring so that they can practice their hunting skills (Caro, 1994). Meerkats behave in a similar manner. Normally an adult meerkat will eat their prey immediately. However, when they have pups the adults will bring dead or injured prey to their pups to allow them to practice their hunting skills. In fact, adult meerkats will catch a scorpion and remove the sting allowing the pups to kill the scorpion safely. Studies have shown that the pups that were given access to the stingless scorpions were more successful at hunting on their own than their siblings who were given dead scorpions. Adult meerkat behavior, also, changes in response to performance of pups. Adults will nudge ignored prey items and then assist their pups by retrieving any escaped prey (Thornton and McAuliffe, 2006).

In a controlled study on cottontop tamarins, Humle and Snowdon (2008) showed one nonhuman primate species capable of teaching its young. For their experiment, they constructed a device using tubes and Styrofoam cups and then trained the tamarin parents on how to successfully get food from the device. After having the parents master the specific foraging technique, Humle and Snowdon observed the parent/offspring interactions, the foraging strategies employed by the offspring, and the rate of success. Humle and Snowdon found that not only did the parents model the strategies that they were taught, but they also used vocal cues to notify their offspring of the available food

sources. The study also showed three cases in which the parents "scaffolded" their teaching. In all three cases, the offspring were having difficulty obtaining the food, so the parents partially solved the problem and then called the offspring to remove the food reward. In all three cases, the offspring were successful at completing the task independently afterwards.

While the previous examples all focused on parent/child relationships there are cases of animals teaching one another into adulthood. When a young female African elephant is struggling to mate for the first time, an older female will simulate estrus to demonstrate proper mating behavior (Byrne and Rapaport, 2011). Bates et al. (2010) observed 999 African elephant estrus events. Out of the 999 events, 10 events were false estrus events (the females were either already pregnant, senescent, or infertile due to lactation) in the presence of a nulliparous (never given birth) female relative. However, 8 events were false estrus events without an observer. Therefore, it is unclear whether the simulation of estrus is a true teaching event. This behavior could just be a result of hormonal changes in the older female, or an attempt by the older female to retain the desirable males for longer periods of time. By keeping the desirable male within the family group, the females can increase chances of copulation or deter young male elephants (Bates et al., 2010).

Is There Teaching in Chimpanzees?

Teaching in chimpanzees is a controversial topic. Several papers address whether there exists teaching in chimpanzees. While most papers agree that many chimpanzee

behaviors and skills are acquired through social learning (through emulation or imitation), there are some papers that argue that teaching does take place in chimpanzees.

Hirata (2009) observed several cases of teaching through inhibition (keeping the offspring from doing something) at the Hayashibara Great Ape Research Institute. When an infant chimpanzee began playing with a chain in her enclosure, the mother chimpanzee approached her daughter and removed the chain from her daughter's hands. This type of behavior was observed several times in this mother-daughter pair until the infant matured and no longer played with the chains. Also, there are cases in which wild chimpanzee infants were seen approaching a plant that was not a part of their diet and the mothers intervened by pulling the infants away from the plant (Hirata, 2009). In both situations, the mothers altered their behavior in the presence of the learner and the offspring learned to stay away from something that could cause them harm.

Boesch (1991) states that in Tai National Park, Ivory Coast, he observed four chimpanzee mothers leaving desirable hammers on anvils for their children to use to crack nuts. According to our definition of teaching, the teacher (chimpanzee mother) changed her behavior in the presence of the learner at her own expense (she had to spend foraging time looking for a new hammer to use) so that her offspring could acquire a new skill. In all four cases, the chimpanzee offspring were more successful at opening the nuts after their mothers intervened. In 1987, Boesch observed a mother chimpanzee named Ricci model the proper way to hold a hammer and how to position the nut so that her daughter Nina could open the nuts more efficiently. Ricci altered her normal behavior by taking a "full minute to perform this simple rotation" of the nut. By changing her behavior in the presence of the naïve learner, it supports our adopted definition of teaching. After this

interaction Nina was able to successfully crack 10 nuts, while maintaining the proper hammer grip her mother taught her. Although studies report examples of teaching in chimpanzees, these reports are very rare, we would expect these examples to be much more common given chimpanzees' sociality, tool use, and intelligence.

On the other hand, Lonsdorf (2006) observed termite-fishing behavior in chimpanzees in the Gombe National Park. While the chimpanzee mothers allowed the children to observe their behavior, Lonsdorf never observed any active teaching or tool sharing between mother and offspring as observed in Tai chimpanzees.

One could speculate that low risk learning does not require the parents to expend the energy in teaching skills. According to Moore (2013) "there appears to be a critical window within which tool techniques can be learned… chimpanzees who do not learn to crack nuts between the ages of three and five do not subsequently do so." Therefore, chimpanzee mothers teach their offspring how to use tools to crack nuts because it is a high-risk behavior unlike termite fishing. This is also supported by the multiple examples of teaching through inhibition. Chimpanzee mothers will actively teach their offspring to avoid things that will do them harm. I share the opinion of Thornton and Raihani (2008), that it is not a case of if chimpanzees can teach their young, but rather do they need to. In other words, since the utility of teaching is low it rarely occurs.

Teaching in Humans

Teaching in humans begins at birth. For example, parents modify the pronunciation of words to help their babies learn to speak. The parent reinforces language development by reinforcing progress and correcting mispronounced words. As the child ages and enters

school they learn a majority of their skills and content through teaching. For example, when teaching cursive to students, a schoolteacher modifies the speed in which they normally write and explains how they are forming the letters on the blackboard. The schoolteacher may even stop what they are doing to help a struggling child properly hold the pencil (Thornton and McAuliffe, 2012).

All the available evidence indicates strongly that teaching in humans is universal across times, places and cultures. Even in traditional hunting and gathering cultures, such as the Aché and Aka, teaching occurs. Both the Aché and Aka societies provide excellent sources to examine how culture has evolved, because their way of life represents a more traditional culture characterized by mobility, small population, minimal age and gender hierarchy, and lack of both storage and strong political leaders. In other words, the hunter-gatherer way of life is more representative of the circumstances under which teaching was utilized most throughout human history. The Aché and Aka are hunter-gatherer societies, respectively living in eastern Paraguay and Central Africa. Studies have provided evidence of teaching across both cultures. For example, an Aché father teaches his son how to build a bow by calling his son over, choosing a wide seat to accommodate the son and shifting his position periodically to allow the son a better view (Byrne and Rapaport, 2011). In Hewlett et al.'s (2011) study of the Aka, they observed parents making "small axes, digging sticks, baskets" which are then given to the infants. As the infants use the tools, the parents watch, make sounds and, at times, step in to modify how to use the tools. Also, the Aka mothers teach their daughters how to identify edible and inedible foods items and how to weave baskets. In 2016, Hewlett and Roulette conducted an observational study to determine whether teaching of infants exists in Aka hunter-gatherers. They observed 169

teaching events and 112 teaching episodes between caregivers and infants within the 10.1 hours of videotapes. They found that infants imitated someone 2 to 3 times per hour and that 68% of imitations occurred during a teaching event. During these teaching events, the infants learned a variety of skills such as, foraging, food preparation, singing, dancing, and tool use. Hewlett and Roulette (2016) determined that teaching is a "regular component of hunter-gatherer learning."

In each of these examples, the teacher modifies their behavior in the presence of the pupil, the teacher does not receive any immediate benefit from the interaction, and the pupil either acquires knowledge or a skill from the interaction. Therefore, these examples satisfy the three necessary requirements for teaching as outlined by Caro and Hauser's definition (1992).

All Teaching in Traditional Human Societies is Nepotism

Historically anthropological research suggested that teaching is rare or does not exist in traditional hunter-gatherer societies. The common belief was that children were expected to learn on their own and the adults would only intervene when the child was not behaving in a socially acceptable manner (Lancy and Grove, 2010). However, recent literature indicates that it does exist (Hewlett et al., 2011). If we consider further the traditional societies of the Aché and Aka, we find that teaching occurs and when it does it represents nepotism, meaning that teaching occurs between closely related individuals; most often between a parent and offspring. In the Aché example of building a bow, teaching occurs between father and son. In the Aka examples, teaching occurs between parents and offspring. In addition, we find more examples of nepotism in teaching across

other hunter-gatherer societies. Konner (1976;2010) described how !Kung (a hunter-gatherer society that live on the western edge of the Kalahari Desert, Ovamboland, and Botswana) teach their infants to sit, walk, and share. Wiessner (1982) also described how !Kung parents removed beads from infants' necklaces and had the infants give the beads to appropriate kin relations so the infants could learn about sharing networks. Among the Inuit (Canadian Eskimo foragers), researchers have also observed teaching (Guemple, 1988). Guemple describes how Inuit mothers' ask their young infants to identify which individual in a room belongs to a particular kinship category, for example an aunt. Other individuals in the room look at the person with that kin term and when the infant looks at the correct person the mother looks approvingly at the infant and cheers. Guemple describes that at 12 months of age, infants are asked to point to particular kin and by 14-18 months a child can identify everyone in the camp by an appropriate kin term. This observation highlights that the Inuit camp likely consists entirely of kin and therefore when a child learns something from someone other than a parent, it is most likely learning from a grandparent, an aunt, or some kind of cousin; therefore, all these examples of teaching represent nepotism.

In addition to qualitative evidence, researchers have also provided quantitative evidence to support the notion that most teaching that occurs in hunter-gatherer societies is based on nepotism. Specifically, Hattori (2010) found that Baka (a hunter-gatherer society in Southeast Cameroon) women said that they learned about the uses of 90 plants from their mothers 80 percent of time, fathers 15 percent of time and others 5 percent of time; Baka men said that they learned about the plants from their mothers 10 percent of the time, fathers 65 percent of the time, siblings 11 percent of the time and others 13

percent of the time. It is important to note, that in hunter-gatherer societies there is a tendency to live among relatives. Therefore, the "others", mentioned in the Hattori study, are most likely still related to the learner (aunts, uncles, cousins, grandparents, etc.). In another quantitative study, Hewlett et al. (2011) surveyed 39 Aka forager children (5-18 years old) asking them to list anyone who taught them to share food. They found on average, 60 percent of the Aka children said that their mothers taught them to share food, 27 percent listed their fathers, 20 percent other kin, and only 3 percent mentioned a non-family member. Although examples of teaching exist in hunter-gatherer societies, Hewlett et al. (2011) highlight that teaching is relatively infrequent by comparison to other processes of social learning such as observation and imitation. Hewlett et al. also discuss the frequency of vertical transmission versus horizontal transmission learning in Aka society. Vertical transmission of social learning is the children learning from parents whereas horizontal transmission of social learning is children learning from individuals who are not parents. Hewlett et al. demonstrate that vertical transmission is the most common mode of social learning in Aka society. Although this evidence is tangential to data on teaching it does provide some evidence that nepotism is the most important route of social learning in Aka society.

Although data are limited, both the qualitative and quantitative data discussed provide evidence that when teaching does occur in traditional human societies it is most often based on nepotism. If we assume that this is the case across all traditional societies, then we can speculate that teaching for pay is not the originally evolved form of teaching in humans. Therefore, teaching for pay (reciprocity-based) must have arisen sometime later in human history.

Interestingly, in Hewlett and Roulette's (2016) research on the Aka hunter-gatherers, two Aka women spent three weeks teaching Hewlett how to weave a small children's basket. This demonstrates the potential for reciprocity-based teaching to develop in hunter-gatherer societies as arguably occurred gradually throughout the historical period (or before) in more urban, non-hunter-gatherer societies.

Modern Professional Teaching is Based on Reciprocity

Similar to traditional societies, all of the examples of teaching in nonhuman animals are examples of nepotism. In addition to teaching in nonhumans and in traditional societies, there are plenty of examples of teaching in modern society that can be explained by nepotism; a parent teaching their baby how to walk, how to pronounce words, explaining the meaning of many words, or home schooling a child are all examples of nepotism-based teaching. One could even argue that paying college tuition is nepotism because the parent is investing in the education of the offspring at their own expense.

However, there is something arguably unique about teaching in humans in modern cultures. The current education system is based on a knowledgeable individual (teacher) working with a group of novices (students). Referring back to our definition of teaching, the teachers modify their behavior in the presence of the students, the teachers receive no immediate benefit from the exchange and then students learn new content and/or skills. Currently, in return for their teaching, teachers around the world are being paid and being promised pensions. Pay and pensions — a promise of future pay — are being traded for teaching, which constitute reciprocity, exactly as Trivers described reciprocity in 1971. In addition, the social status associated with teaching is indirect reciprocity, exactly as

Alexander described it in 1987. Humans are the only species that have teaching on a reciprocity-based system where the teacher and learner are no longer related to one another. This fact makes one think about how teaching evolved in humans into a reciprocity-based system. As speculated earlier, teaching for pay is likely not the originally evolved form of teaching in humans. Therefore, teaching for pay must have arisen sometime later in human history.

The difficulty in understanding the evolution of education in human society is the lack of evidence of the role of teaching in prehistoric and pre-industrial human societies. While there is anthropological literature about pre-industrial societies, and it does include information about many things in those societies (e.g., resource base, religious practices, housing, etc.), it very rarely includes information about teaching. One could speculate that with advancements in technology and agriculture, humans were able to live in larger groups. This allowed for an increase in trading resources. Then as societies advanced and people began to specialize in certain skills, education and the knowledge transfer of skills became a traded resource as well. Eventually, humans moved away from the nepotism of parent/child education to a reciprocity-based or payment-based system. The following are just a few examples of early civilizations with evidence of a transition from nepotism-based to reciprocity-based systems of education.

In India, during the Vedic Period (1700-150 BCE) most young boys began their primary education at the age of 5, usually within their own homes. At age 11, they begin their Vedic studies. Unless born into a priestly family, the boy would leave home at this time to live with his teacher to complete his education. Religion, debate and discussions were the major focus of the Hindu Education System. The Vedas were passed down orally

from a Guru. Written versions of the Vedas only appear late in the history of the Vedas around 800-1000 CE (Witzel, 1997). The teachers were paid wages by their student's families. The "world-renowned" teachers, whose students were sons of kings or merchant princes, would earn about 1,000 coins per student. These teachers would sometimes have about 500 students under them, making them very wealthy. However, the average Sanskrit teacher usually only had about 20 students, whose parents must have offered much less. In order to ensure the preservation of their traditions these studies became a requirement for marriage (Altekar, 2009).

In Archaic Greece (700-480 BCE) most free non-elite Greeks learned the occupation of their fathers. During this time, most sons learned their trades "within the family or through apprenticeships." In 6th century BCE, Solon, an Athenian statemen, "was credited with legislating a requirement that fathers educate their sons in a craft or lose the right to be supported by them in old age." In 387 BCE, Plato proposed a new system of education: grouping students into one of three choruses. The chorus would consist of 8-15 members of the same sex. They would be taught by one adult instructor. The funding for these teachers varied, but most came from the participants own families or from wealthy individuals who acted as patrons for their local community (Griffith, 2001).

In early Roman culture the father, as head of the household, was responsible for the education of the children. Since "the family" was at the center of Roman culture, institutionalized education developed much later than other civilizations (Chiappetta, 1953). Early evidence of schools appeared around the time of 1 BCE and 1 CE. During this time, most Roman children would begin their formal education at age 7 with the litterator where they would learn the 3 R's: reading, writing and arithmetic. Formal schooling for

most Roman children ended with the litterator because their parents needed them to start working and earning money. The child would either stay home and be trained for work by his father or sent away to an apprentice to learn a craft (Shelton, 1998). Some boys, from wealthier families, would move on to the grammaticus at age 11 and even fewer would continue on to the rhetor at age 15 (Eyre,1963). Roman schools were privately financed and varied greatly in quality. Teachers either rented out classroom space in buildings or taught outdoors on sidewalks and piazzas (Shelton, 1998). In very rich families, the children were taught at home by an educated slave or a visiting litterator.

In Medieval France, children were taught the letters of the alphabet by their mothers before beginning elementary school. Once in school the children would learn how to pronounce syllables, read and memorize certain prayers. The treatment of teachers varied greatly; "rich or poor, male or female, respected or ostracized, and even educated or ignorant" (Lynch, 2017). It seems that the treatment of the teacher depended on who and what they taught and their own economic status and education level. For example, teachers who were supported by the municipal government were seen as important members of the community and would own large houses (paid by the city) and teach the town's elite members. The city of Leon would hire the best teachers available in order to earn a reputation as a place of learning. Therefore, paying their teachers well was mutually beneficial.

In some ways we can see the transition from nepotism only to nepotism plus reciprocity continuing on into modern times. There are always discussions between parents and professional teachers about how much and what kind of teaching is supposed to be covered by the contract. Even if it is not in the formal contract, there may be informal

expectations in regard to parental-type instruction from professionals. For example, there are always social interactions between students that are monitored by teachers which are not really part of formal teaching. In addition, there are often after-school programs involving sports and specialty clubs in which there may be more of a parental or coaching role expected. Some families may hire professional tutors and, depending on the time and place and contract, some of these tutors may be expected to carry out parental-type duties. At the extreme are boarding schools, where the students, often young students, are away from their actual parents. If there are any parental functions needed, they typically fall on the professional teachers, at least until the parents can be contacted. In all of these cases there is often disagreement between parents and teachers about how much of traditional parental responsibilities teachers are expected to perform.

Conclusively, modern teaching is based on reciprocity. This does not occur in nonhuman animals and it also is probably relatively new to humans – as speculated earlier, ancestral human teaching was likely based on nepotism.

A Broken System: Modern Teaching in the United States

Studies have shown a dramatic decrease (35% nationwide in the last 5 years) in student enrollment in teacher preparation programs. In addition, 19-30% of new teachers leave the profession within their first 5 years of teaching (Sutcher et al., 2016). In the past, school districts dealt with teacher shortages by increasing class sizes, eliminating art and music programs and hiring short-term substitutes. However, as student enrollments are projected to grow by 3 million in the next decade due to increases in birth and immigration rates, the short-term solutions school districts used in the past will no longer suffice.

Therefore, there needs to be a change in the political climate surrounding teaching in the United States.

Based on the past research discussed in this paper, I suggest that a potential approach to improve the teacher shortage crisis is to focus on why humans teach. As mentioned earlier, the central question when discussing cooperation is — how does the cooperator (i.e. teacher) who took on a cost eventually benefit? In other words, how do teachers benefit? We know that the two main reasons why humans teach are reciprocity (payment) and indirect reciprocity (social status). Our current educational system is broken because neither of these conditions are being met sufficiently. In terms of reciprocity, teacher salary should reflect that of other professions so that teachers can make a reasonable living. For example, a study found that public school teachers' weekly wages were 17.0 percent lower than those of comparable workers— compared with just 1.8 percent lower in 1994 (Allegretto and Mishel, 2016). Another form of payment that teachers receive are pensions. A pension is a fund into which a sum of money is added during a teacher's employment years and from which payments are drawn to support the teacher's retirement from work in the form of periodic payments. However, studies have found that pension systems are severely underfunded; most teacher pension plans have made many promises of future benefits that are not adequately funded (Doherty et al., 2012). This situation is an example of the kind of cheating that Trivers (1971) explained was the big risk in reciprocity. Teachers are teaching for salaries that are below what the market alone would dictate, and then teachers are left with substandard lifetime compensation because their pensions are reduced below the contract level at the time of

retirement. Teachers are not appropriately compensated for their work and therefore the reciprocity-based system breaks down because the necessary criteria are not met.

In terms of social status, public school teachers in the United States are highly educated, a bachelor's degree and completion of a teacher preparation program being a requirement to teach in most states. In addition, teachers must pass a rigorous set of exams and undergo teaching evaluations prior to beginning their careers. Throughout their careers they also participate in professional development to continue to improve their specialized skillset. However, the profession does not receive the same prestige as other comparable specialized professions. One potential reason for the difference and arguably lower social status would be the compensation associated with teaching. Another potential reason is the current focus of the educational system, which is on measuring a teacher's success through high-stakes testing. The higher the stakes, the more schools focus instruction on the tests. As a result, what is not tested often is not taught. Whole subjects may be dropped; e.g., art or physical education may be eliminated if only language arts and math are tested. Good teachers are often discouraged, even disgusted, by the overemphasis on testing. Teachers are reduced to teaching test prep and as a result, many excellent teachers leave. Moreover, when tests are the only evaluation used to hold schools accountable, teachers begin to leave low-performing schools where they are needed most; this leads to the creation of a vicious cycle where the low-performing schools get worst and high-performing get better. Undisputedly, people have the right to know how well schools are doing, but tests fail to provide sufficient information. Across the United States, the obsession on high-stakes testing has caused important subjects to be pushed aside and our schools once vibrant centers for learning have truly been reduced to test prep factories.

Consequently, as public opinions changed to view schools in this manner the social status of teachers declined.

Improving the current state of the educational system must first begin with policy makers recognizing that the system is broken. To truly understand the issues with the system it is necessary to understand the underlying mechanism and the necessary criteria that need to be met. Our teaching system is reciprocity-based and therefore teachers must receive the appropriate compensation both directly (salary and pensions) and indirectly i.e. social status. In addition to making improvements in compensation, it is important to develop strong mentoring and teacher preparation programs. By supporting our teachers and allowing teachers to have input in decision-making, we can hopefully influence teachers to continue serving our school communities. Lastly, it is important to note that teachers enter this profession not just for the pay, which is relatively poor, but also with a strong altruistic component in the form of a desire to impart knowledge to the next generation. It is the job of the educational system to ensure that teachers are supported because if not it will be the students that suffer.

Conclusion

This review of teaching in nonhumans and humans strongly suggests that the original form of human teaching was based on the same payoffs to teachers as nonhuman teaching. In nonhumans and humans everywhere, there are payoffs to teachers through nepotism. In human hunter-gatherer societies it appears that the payoffs to teachers are from nepotism. However, in some human societies, such as the modern U.S., professional teachers exist and are teaching non-relatives and being paid for their work. The payoffs to

these kinds of teachers come from reciprocity. The transition from a system based on nepotism only, to a system that also includes reciprocity-based payoffs for professional teachers is difficult to pinpoint, but it seems clear that there was such a transition. In some ways the transition is ongoing. There will likely always be human nepotism-based teaching, and there will likely also always be ongoing negotiations about how much teaching, what kind teaching, and the context of teaching that professional teachers are contracted to do. Professional teachers must receive appropriate compensation both directly and indirectly, both in the present and the form of promises of future benefits. In the U.S. at present there is something of a broken system. Low salaries, underfunded pensions, and high-stakes testing, all contribute to the broken system. Recommendations for how to improve the system are also discussed. I hope this paper can be used as a foundation for teachers, researchers, and policy makers to understand the underlying mechanisms that affect and influence our education system in the United States.

References

1. Allegretto, S. A., & Mishel, L. (2016). The teacher pay gap is wider than ever: Teachers' pay continues to fall further behind pay of comparable workers. *Economic Policy Institute*.
2. Alexander, R. D. (1987). The biology of moral systems. *New York: Aldine De Gruyter.*
3. Altekar, A. S. (2009). *Education in ancient India*. Gyan Publishing House, 47-60.
4. Bates, L. A., Handford, R., Lee, P. C., Njiraini, N., Poole, J. H., Sayialel, K., .. & Byrne, R. W. (2010). Why do African elephants (Loxodonta africana) simulate oestrus? An analysis of longitudinal data. *PLoS One*, *5*(4), e10052.

5. Boesch, C. (1991). Teaching among wild chimpanzees. *Animal Behavior*, 530-532.
6. Byrne, R. W., & Rapaport, L. G. (2011). What are we learning from teaching?. *Animal Behavior*, *5*(82), 1207-1211.
7. Caro, T. (1994). Cheetahs of the Serengeti Plains: group living in an asocial species. *University of Chicago Press,* 136-140.
8. Caro, T. M., & Hauser, M. D. (1992). Is there teaching in nonhuman animals?. *The Quarterly Review of Biology*, *67*(2), 151-174.
9. Carter, G. G., & Wilkinson, G. S. (2013). Food sharing in vampire bats: reciprocal help predicts donations more than relatedness or harassment. *Proceedings of the Royal Society B: Biological Sciences*, *280* (1753), 20122573.
10. Chiappetta, M. (1953). Historiography and Roman Education. *History of Education Journal, 4*(4), 149-156.
11. Danchin, É, Giraldeau, L., Valone, T., & Wagner, R. (2004). Public Information: From Nosy Neighbors to Cultural Evolution. *Science, 305* (5683), 487-491.
12. Doherty, K. M., Jacobs, S., & Madden, T. M. (2012). No one benefits: How teacher pension systems are failing both teachers and taxpayers. *Washington, DC: National Council on Teacher Quality*.
13. Dugatkin, L. A. (1997). Cooperation among animals: an evolutionary perspective. *Oxford University Press on Demand,* 355-362.
14. Eyre, J. (1963). Roman Education in the Late Republic and Early Empire. *Greece & Rome, 10*(1), 47-59.
15. Galef Jr, B. G. (1995). Why behavior patterns that animals learn socially are locally adaptive. *Animal Behavior*, *49*(5), 1325-1334.

16. Griffith, M. (2001). Public and private in early Greek institutions of education. *Education in Greek and Roman antiquity*, 23-84.
17. Guemple, L. (1988). Teaching social relations to Inuit children. *Hunters and Gatherers*, *2*, 131-149.
18. Hamilton, W. D. (1964). The genetical evolution of social behavior. II. *Journal of Theoretical Biology*, *7*(1), 17-52.
19. Hattori, S. (2010). "My medicine (ma a le)": variability of medicinal plant knowledge among adult Baka hunter-gatherers of Southeast Cameroon. *African Study Monographs*.
20. Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter–gatherers. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1567), 1168-1178.
21. Hewlett, B. S., & Roulette, C. J. (2016). Teaching in hunter–gatherer infancy. *Royal Society Open Science*, *3*(1), 150403.
22. Hirata, S. (2009). Chimpanzee social intelligence: selfishness, altruism, and the mother–infant bond. *Primates*, *50*(1), 3-11.
23. 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.
24. Humle, T., & Snowdon, C. T. (2008). Socially biased learning in the acquisition of a complex foraging task in juvenile cottontop tamarins, Saguinus oedipus. *Animal Behavior*, *75*(1), 267-277.
25. Konner, M. J. (1976). Maternal care infant behavior and development among the !Kung.

26. Konner, M. J. (2010). The evolution of childhood: Relationships, emotion, mind. *Harvard University Press.*

27. Lancy, D. F. & Grove, M. A. (2010) The role of adults in children's learning. In *The anthropology of learning in childhood.* Rowan & Littlefield, 145-180.

28. Lonsdorf, E. V. (2006). What is the role of mothers in the acquisition of termite-fishing behaviors in wild chimpanzees (Pan troglodytes schweinfurthii)?. *Animal Cognition*, *9*(1), 36-46.

29. Lopez, J. C., & Lopez, D. (1985). Killer Whales (Orcinus orca) of Patagonia, and Their Behavior of Intentional Stranding While Hunting Nearshore. *Journal of Mammalogy, 66*(1), 181-183.

30. Lynch, S. (2017). Teachers in Lyon. In *Elementary and Grammar Education in Late Medieval France: Lyon, 1285-1530*. Amsterdam: Amsterdam University Press, 67-106.

31. Moore, R. (2013). Social learning and teaching in chimpanzees. *Biology & Philosophy*, *28*(6), 879-901.

32. Nicol, C. (2006). How animals learn from each other. *Applied Animal Behavior Science*, *100*(1-2), 58-63.

33. Radhakrishnan, S. & Moore, C. (1957). The Vedas: A Source Book in Indian Philosophy. New Jersey: Princeton University Press, 3-36.

34. Rendell, L.E. & Whitehead, H. (2001) Culture in whales and dolphins. *Behav. Brain Sci.* 24, 309-382.

35. Sachs, J. L., Mueller, U. G., Wilcox, T. P., & Bull, J. J. (2004). The evolution of cooperation. *The Quarterly Review of Biology* 79: 135-160.

36. Shelton, J. (1998). As the Romans did: a sourcebook in Roman social history. New York: Oxford University Press, 100-122.
37. Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). A coming crisis in teaching? Teacher supply, demand, and shortages in the US. *Learning Policy Institute.*
38. Terkel, J. (1996). Cultural transmission of feeding behavior in the black rat (*Rattus rattus*). *Social Learning in Animals: The Roots of Culture*, 17-47.
39. Thornton, A., & McAuliffe, K. (2006). Teaching in wild meerkats. *Science,* 313, 227-229.
40. Thornton, A., & McAuliffe, K. (2012). Teaching can teach us a lot. *Animal Behavior, 83, e6-e9.*
41. Thornton, A., & Raihani, N. J. (2008). The evolution of teaching. *Animal Behavior*, *75*(6), 1823-1836.
42. Trivers, R. L. (1971). The evolution of reciprocal altruism. *The Quarterly Review of Biology*, *46*(1), 35-57.
43. Whiten, A. (2017). Social learning and culture in child and chimpanzee. *Annual Review of Psychology*, *68*, 129-154.
44. Wiessner, P. (1982). Risk, reciprocity and social influences on Kung San economics. *Politics and history in band societies, 61-84.*
45. Wilkinson, G. S. (1984). Reciprocal food sharing in the vampire bat. *Nature, 308*(5955), 181.
46. Witzel, Michael. (1997). The development of the Vedic canon and its schools: the social and political milieu. *Inside the Texts, Beyond the Texts.* Cambridge: Harvard University, 258-260.