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Teaching strategies are shaped by experience with formal education: Experimental evidence from caregiver-child dyads in two Tannese communities

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Abstract
Humans are extraordinary in the extent to which we rely on cumulative culture to act upon and make sense of our environment. Teaching is one social learning process thought to be fundamental to the evolution of cumulative culture as a means of adaptation in our species. However, the frequency of teaching and how we teach are known to vary across human sociocultural contexts. Understanding this variation adds to our understanding of the complex interplay between cognition and culture in shaping learning behavior but also contributes to theory around the costs and benefits of different social learning processes. Here, we examined how prior experience with formal education is related to the frequency and diversity of teaching behaviors in an experimental paradigm where caregivers were motivated (but not instructed) to teach a simple skill to a child (7–10 years old). We identified and coded a suite of subtle nonverbal behaviors that could be construed as facilitating learning. Dyads ($n = 64$) were recruited from two communities on Tanna Island that differ in their experience with formal schooling and their acceptance of Western institutions. We found evidence for parallel teaching strategies in both communities. However, the rate and diversity of teaching behaviors were positively associated with caregiver's experience with formal schooling and independently and negatively associated with being from a village that rejects Western-derived institutions. These results further our understanding of how multiple cultural processes influence social learning and highlights the powerful influence of formal schooling on the cultural evolution of teaching in humans.

Keywords Teaching · Culture · Cumulative cultural evolution · *Kastom*, Vanuatu

More than any other species, humans rely on cumulative culture for survival and adaptation, which many argue has shaped our cognition (Boyd et al., 2011; Dean et al., 2014; Tomasello, 1999; Whiten & Erdal, 2012). For example, we use complex tools and knowledge to locate, extract, and cultivate resources in our environments, and we organize interaction between individuals and groups through elaborate institutions and highly varied social norms. Such foundational features of human life cannot be learned by naïve individuals without high-fidelity social learning (Boyd & Richerson, 1985; Burdett et al., 2018; Caldwell et al., 2018; Nielsen, 2012; Tomasello et al., 1993; Whiten et al., 2009). In particular, it appears humans make use of a uniquely diverse and efficient set of strategies and behaviors for teaching (Bridgers et al., 2020; Burdett et al., 2018; Csibra & Gergely, 2011; Dean et al., 2012; Premack et al., 1996; Ronfard et al., 2016; Ronfard & Harris, 2018; Strauss & Ziv, 2012). Notably, however, much of the research on teaching and its role in shaping human cognition and its diversity across time and space has been done in so-called WEIRD populations (Henrich et al., 2010), limiting our ability to generalize. In this study, we examined the frequency and diversity of teaching behaviors among two communities of Tanna Island, Vanuatu, where the major relevant difference between the two communities is the degree of participation in formal, Western-style schooling. As we expand on below, such formal schooling is an educational institution characterized by a relatively greater emphasis on teaching than is found in other sociocultural contexts.

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Broadly, we define teaching as the modification of behavior in order to focus the attention and direct the behavior of others to facilitate learning (Caro & Hauser, 1992; Hewlett & Roulette, 2016; Kline, 2015; Thornton & Raihani, 2008). In general, teaching is a high-fidelity social learning process because it narrows the search space for a learner, helping them to identify a specific learning goal and a specific means of reaching that goal (Bonawitz et al., 2009; Gopnik et al., 2017). As such, teaching may be especially useful in transmitting conventional cultural traits whose means–end relationship or function is not transparent (Gergely & Csibra, 2006). However, human populations vary significantly in the frequency that teaching is used in general and in the diversity of teaching behaviors commonly used to help others learn (Boyette & Hewlett, 2017; Clegg et al., 2021; Kramer, 2021; Lancy, 2016). In particular, anthropologists and cross-cultural psychologists have emphasized the extent to which children in face-to-face subsistence societies—such as the Tannese, with whom we worked for this study—learn through observation and hands-on participation in everyday social and economic activities of their family and community without teaching (Gaskins & Paradise, 2010; Lancy, 2010, 2012; Lave & Wenger, 1991; Ochs & Izquierdo, 2009; Paradise & Rogoff, 2009). Teaching as defined by us occurs in these contexts but tends to occur far less frequent than observational learning, and to be subtle, brief and specific to specialized instrumental tasks, complex ecological knowledge, or opaque conventions and social norms (Boyette & Hewlett, 2018; Guemple, 1988; Maynard, 2002; Tehrani & Riede, 2008). In these contexts, the emphasis is placed on children's experiential learning, so teaching behavior is largely to facilitate children's individual learning, such as through giving a child a tool or showing what they should imitate. In contrast, within formal schooling, language is nearly the exclusive means of information exchange, learning is via heavily cognitive modes (versus through physical action) and in the abstract, and adults are situated as the sole sources of cultural knowledge to which children must attend (Scribner & Cole, 1973).

These contrasting social learning contexts and their differing emphases on teaching are also socially learned and result in different expectations about how children learn and should be taught (Greenfield et al., 2000). Experience with formal schooling itself is associated with a particular style of more involved, top-down teaching. For example, Paradise et al. (2014) found that teachers who come from cultural backgrounds emphasizing observation and participation demonstrated a style of teaching in which they support children's initiative, adjust the pace of teaching in relation to children's learning, and use nonverbal cues. In contrast, teachers with pedagogical experience in the American formal school system attempted to control children's attention and motivation, provided step-by-step direct, verbal instruction, and praised good performance. Clegg et al. (2021) found similar contrasts between American and Tannese parents in the ways in which they worked with their child in a tangram puzzle game. The former used a greater diversity of teaching behaviors (e.g., facilitation, encouragement, planning), and the interaction was more frequently led by the caregiver than it was among the Tannese. In contrast, the Tannese caregivers largely pointed and used imperatives to direct the child's behavior, and more in preparation for the task than during.

In short, although there are some behavioral commonalities in teaching and learning across cultures, past research also finds that humans learn to learn and teach in ways specific to their sociocultural contexts (Mesoudi et al., 2016). As different forms of learning are central to socialization, they also tend to be reinforced by cultural values and, in turn, reinforce these values (e.g., for autonomy vs. hierarchy; Boyette & Hewlett, 2017). Specifically, children who grow up in contexts emphasizing formal, school-based learning tend to be more extrinsically motivated (Coppens & Alcalá, 2015; Ochs & Izquierdo, 2009), and attend only to teaching directed at them, following this closely rather than exploring alternative possibilities (López et al., 2010; Shneidman et al., 2016; Silva et al., 2010). This learning style may effectively prepare children for an environment in which survival is based on specialization within a highly competitive, meritocratic labor market (Bowles & Gintis, 1977, 2002). However, this relatively rigid and costly educational practice may amplify social inequalities (Croizet et al., 2019; Jackson & Holzman, 2020), disadvantage those with learning differences (Cainelli & Bisiacchi, 2019; Shifrer, 2013), and lead to decreases in mental health and children's well-being (Boyce et al., 2012; Gray, 2013; Narvaez et al., 2012). In its focus on variation between otherwise highly similar communities (e.g., same economy, natural ecology, social systems), the current study adds to our understanding of the mechanisms through which downstream changes to learning dynamics emerge in relation to formal schooling.

To meet this aim, we examined the behavioral elements of teaching using an experimental approach, working with two neighboring communities from Tanna, Vanuatu, a small-scale, non-Western society whose experience with formal schooling and cultural values around Western institutions vary. Previous studies have shown that Tannese parents and children teach and learn in ways more consistent with the intent participation tradition's emphasis on observational learning and minimal intervention in comparison with American parents and children (Clegg et al., 2021; Little et al., 2016). However, as noted, experience with schooling varies in Tanna, as do values for local versus Western-derived institutions and beliefs. Specifically, certain villages identify as *kastom*, and actively reject colonial institutions and Western schooling (see Sociocultural contexts below). Comparing kastom to self-identified "traditional" villages

offers an opportunity to examine multiple dimensions of variation in teaching within a small-scale, non-Western society where an intent participation tradition of learning most skills predominates alongside opportunities for formal schooling. In this study, we used a quasi-experimental approach in which adults (i.e., caregivers) were given the opportunity to teach a child a novel skill—producing an origami figure. In our analysis, we focused on the nonverbal, behavioral aspects of caregivers' teaching. Using a Bayesian factor modeling approach, we explored the latent structure of these behaviors to identify "styles" of teaching. Then, we examined the relationship between experience with formal education and teaching behaviors.

Specifically, based on the above review of formal schooling versus intent participation traditions, we test the following hypotheses:

1) Tannese caregivers' years of formal schooling is positively associated with a pedagogical approach involving more direct intervention in children's learning.
2) Conversely, caregivers' years of experience in formal schooling is negatively associated with a pedagogical approach which emphasizes children's observation and trial-and-error, autonomous learning.
3) Finally, caregivers' years of formal schooling is positively associated with the diversity of teaching behaviors used by caregivers.

Additionally, we also formally explore the relationship between kastom identity, formal education, and teaching by examining:

a) whether village type has an independent effect on frequencies or diversity of teaching behaviors,
b) whether village type moderates the relationship between education and teaching, and
c) whether emphasis on a certain teaching style varies by village type.

Methods

Overview

We examined caregivers' teaching behaviors in two communities that vary in formal schooling experience using an experimental paradigm designed to motivate them to teach. We recruited 64 caregiver–child dyads from neighboring villages on Tanna, Vanuatu. Due to the complexity of gendered cultural norms in this region at various ages, we had same-gender caretaker–child pairs for this study. The paradigm involved learning and teaching how to make a basic origami figure (a dog) in order to earn a small prize (see Fig. 1). We selected an origami figure as we expected that most participants would not be familiar or have any expertise making origami therefore creating an ideal learning scenario. Also, as with most origami figures, they are easy to learn with the assistance of a teacher or pedagogical cues in a video, but difficult to learn via observation and imitation. One of the authors was also part of a larger project investigating culture and the mind where we used a similar experimental procedure to investigate teaching across cultures in adults (manuscript is currently unpublished). To learn how to make the origami dog, caregivers watched a real-time video of hands making the figure without providing any pedagogical cues. The goal was to have the caregivers learn how to make this origami figure but not prompt them to provide pedagogical cues themselves. Then, they were given an opportunity to practice together with their children (referred to as the PRACTICE SESSION). The dyads were instructed that the goal of the practice session was for the child to learn how to make the origami dog so that they could produce the dog without caregiver assistance in the next session. Hence, they would be motivated to teach and learn, without explicit instruction to do so. After the caregiver and child indicated that they were ready to move onto the next test session, we allowed them a fixed amount of time for the child to produce the origami dogs. For this study, our main interest was caregivers' pedagogical behaviors during the practice session. Additionally, we asked the caregivers not to speak with the children in order to keep the types of teaching codable to trained research assistants who are unfamiliar with the languages in Vanuatu, which is the most linguistically diverse region of the planet per capita (Posth et al., 2018). The sessions were video recorded. We later watched those videos and coded (a) how much caregivers slowed down while they were teaching (compared with the baseline duration; see Behavior Coding section below and Table 1), (b) how much visual attention they gave to the child, and (c) the overt pedagogical behaviors they produced (i.e., pointing

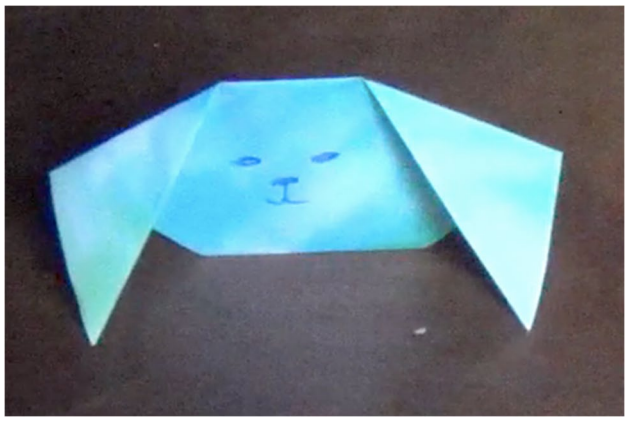

Fig. 1 Image of origami dog figure

Table 1 Ethogram describing behaviors coded in the study

Code	Operational definition	Calculation method
Slowing down	The magnitude of change in the time the caregiver took for making one origami when they had a motivation to teach.	The ratio of the duration of making one origami during Phase 3 to the duration of making one origami during Phase 2
Visual attention	A relative score of how much the caregiver visually attended to the child during teaching.	The proportion of 3-s intervals during which the caregiver looked towards the direction of the child's origami or the child's face during Phase 3
Pedagogical behaviors		
Pointing with finger	The caregiver produced a full finger extension or used a pen to direct the child's attention to a specific location (e.g., the corner of the origami paper).	The frequency at which each behavior was observed per minute during Phase 3
Pointing with face	The caregiver tilted their head in order to direct the child's attention to a specific location (e.g., the model origami).	
Touching	The caregiver touched the child (e.g., on the arm).	
Positive feedback	The caregiver confirmed the child's action with a nod or other locally recognized movement indicating affirmation, such as raised eyebrows.	
Negative feedback	The caregiver gave corrective feedback with a gesture such as head shake	
Waiting	The caregiver paused after they completed an action or while they were in the middle of it at least for three seconds to allow the child to catch up.	
Repeating	The caregiver unfolded and repeated the fold or they repeated a flip.	
Expediting	The caregiver did something to facilitate the child's origami making or guided them in the process. For example, they may have brought the model closer to the child, changed the direction of their origami to allow the child a better view, or they may have directly manipulated the child's origami and made the fold themselves. Tapping the table with their hand or other non-pointing gestures to communicate shape or direction to the child were also coded as expediting.	
Verbal input	The caregiver made a verbal comment even though it was forbidden.	

with finger, pointing with head, giving positive feedback, giving negative feedback, repeating, waiting, expediting, touching, use of speech).

Sociocultural contexts

The second author collected the data in July 2015 on Tanna Island, Vanuatu. Tanna Island is in the Tafea province of the Republic of Vanuatu, located in the South Pacific. A typical village on Tanna consists of several hamlets and each hamlet consists of several households that make up an extended family. Each village is led by a hereditary chief. Families rely on horticulture and small cash crops for a living. At the time of data collection, there was no electricity in the villages, and access to the nearest town was a 2-hour walk. Our research was conducted in the neighboring self-identified "kastom" and "traditional" villages within central Western Tanna and only a few kilometers apart. The primary cultural differences between these villages are the degree of participation in formal schooling and the adoption of Christian practices. In particular, most caregivers from the traditional villages have some formal schooling experience and literacy skills, and nowadays all children attend school at least for the first 5 years, which is free to residents. In contrast, kastom villages do not participate in formal schooling and most adults have no literacy skills, although nowadays some families from these villages chose to send their children to school. Despite this difference, both kastom and traditional villages show a strong commitment to historically shared traditions and lifestyle. In most other respects, daily life is similar socially, culturally, and economically. Residents of kastom and traditional villages interact on a daily basis and maintain harmonious relationships. They participate together in exchange rituals and celebrations, and marriages between villages are common. As such, these two communities are excellent comparison groups to observe how teaching strategies are affected by experience with formal schooling.

Procedure

The second author trained a local female adult (RI) to run the study procedure and closely supervised the data collection by watching the testing in an unobtrusive manner. RI was a local woman affiliated with the Cultural Center branch in Tanna, had good relations with the villagers, and spoke English fluently. RI ran the testing in Natuar—a dialect of the Lenakel dialect chain spoken in West Tanna (Lynch, 1978) and her first language. Although our participants from kastom villages were native speakers of a different dialect chain, adults are typically multilingual in each other's languages. Therefore, the procedure was run in Natuar in kastom villages as well. However, children were not always fluent in Natuar depending on their level of exposure. In order to ensure full comprehension by children, in one of the villages (i.e., Yakel), we asked caregivers to repeat the instructions to their children in their native language. With two participants from traditional villages, we ran the procedure in Bislama (the official language of Vanuatu) due to participants' preference.

The study procedure and instructions were translated from English to Natuar in two steps. First, the procedure was translated from English to Bislama and back translated from Bislama to English, by two separate local research assistants who were fluent in both languages. Any inconsistencies were resolved through discussion. Once the Bislama text reflected the intended study procedure, it was translated from Bislama to Natuar and back by two separate local research assistants. Again, inconsistencies were resolved through discussion. The translations between Bislama and Natuar were conducted orally since Natuar is an oral language, and the process was videotaped for documentation purposes.

We recruited participants through word of mouth. Typically, the second author and RI sent a messenger to a neighboring village before the day of the visit and waited for the answer that they were welcomed. Once in the village, the second author and RI were greeted by the village chief who learned about the study procedure and gave the researchers permission to recruit in their village. For one village that was located near a school building, we followed a different procedure. We first invited the chief to participate in our study with his son. Then, the chief sent a message to his village and invited caregivers to the school building to participate in the study. RI explained the details of the study to interested caregiver–child pairs before asking caregiver's verbal consent and child's verbal assent. The instructions stated that study involved playing a game where participants could earn a small prize by making easy origamis.

The procedure had four phases. In phase one, the caregiver learned how to make a basic origami figure (a dog) by watching a video while the child waited outside the testing area. The video was silent, did not provide any pedagogical cues, and was too fast for a novice to learn in real time. Therefore, the experimenter paused or replayed the video for the caregiver whenever requested. The origami figure involved four folds and a simple face drawing. A completed model of the final product was displayed on the table and remained there throughout the duration of the study. Additionally, a large pile of origami papers was available for practice. Once the caregivers indicated that they had practiced enough, they were asked to make one on their own, without watching the video (Phase 2), indicating that they had indeed learned how to make the origami dog. This phase served as the baseline for determining how much the caregiver slowed down when they "taught" the child to make one (see the Behaviors Coded subsection below). In phase three, the experimenter called the child in and told the dyad

that they were now allowed to practice together without talking to each other and that later, the child would make origamis on their own in order to earn a small prize for the team. This instruction was given in order to increase parents' motivation to teach during the practice phase. Next, the experimenter provided some additional origami papers for the child and left the dyad alone for 5 minutes. This phase served as the experimental condition and provided us with (a) the duration for making an origami when a teaching motivation was present (used to calculate the slowing down variable; see below), and (b) an opportunity to observe pedagogical behaviors produced by the parent. Once the practice time elapsed, the experimenter came back and told the dyad that it was time for the "contest." The caregiver was allowed to stay with the child, but they were not allowed to talk to the child or assist the child in any way. Regardless of the number of origami figures they were able to produce, each child received between 300 and 500 Vatu (equivalent to 3–6 Canadian dollars).

We tested participants either in their homes, a communal kitchen, or a suitable, quiet, open area in the village. At the school building, we were given an empty room with a desk. The procedure was video-recorded with a camera that was positioned at a distance of approximately 2 meters, directly facing the participants. The experimental procedure lasted approximately 20 minutes.

Participants

Sixty-six same-gendered caregiver–child dyads participated in this study. Two of these were excluded from the dataset due to experimental error, resulting in a sample of 64 dyads (34 female–female, 30 male–male). Thirty-three of these dyads were recruited from traditional villages and 31 from kastom villages. Caregivers' mean age was 36.03 (SD = 10.44, range: 19–70). The caregiver was typically a mother (n = 16 in traditional, n = 14 in kastom) or a father (n = 8 in traditional, n = 13 in kastom). Whenever a mother or a father was not available for testing (n = 13), we recruited another regular caregiver such as a grandparent (n = 3 in traditional, n = 1 in kastom), an older sibling (n = 1 in traditional, n = 3 in kastom), or another relative[1] (n = 5 in traditional). Sex of the dyads sampled was relatively even across the villages; we recruited 19 female dyads in traditional villages and 15 in kastom villages.

Demographic information was collected through a short questionnaire which we implemented at the beginning of the study. Therefore, parents' age and schooling experience as well as children's age and school grade were from parent report (unless we recruited children at school). Whenever possible, we asked parents to show us their children's birth certificate; however, this was not reliably available to parents. As expected, both caregivers and children had significantly greater education among the dyads from *traditional* villages (caregivers, $t = -9.5$, $p < .001$; children, $t = -7.03$, $p < .001$; Welch two-sample t test). In traditional villages caregivers reported an average of 6.33 years (SD = 3.21) of schooling (range: 0–13, $\tilde{x} = 6$), and 87.9% of these caregivers reported having literacy skills (n = 29). All children were attending school; 18 were in kindergarten, 14 were in the first grade, and one child was in the second grade. In kastom villages, on the other hand, caregivers reported having 0.58 years (SD = 1.32) of schooling experience on average (range: 0–5, $\tilde{x} = 0$), and only 6.7 % reported having literacy skills (n = 2). We did not have schooling data for four children. Among the rest, only six children were attending school (three kindergarten, three first grade), and 21 were not attending school (77.8%). Caregivers' age was 36.83 years (SD = 10.44) on average (range: 19–70 years) and was comparable between kastom and traditional villages, $t(1, 62) = .60$, $p = .553$. A comparison of children's ages between traditional and kastom villages was marginally significant, $t(1, 61) = 1.94$, $p = .057$, mainly because we tested one 9-year-old and one 10-year-old child in a kastom village.

Coding and reliability

Coders watched the videos on the Datavyu (Datavyu Team, 2014) and ELAN (2021) programs (see details under the coding subsection below). We examined caregivers' teaching behaviors in terms of (a) slowing down, (b) visual attention to the child, and (c) production of overt pedagogical cues. The data were coded by the second author in three separate passes, and two additional research assistants coded portions of data for the purpose of establishing interrater reliability.

Behaviors coded

Table 1 shows the ethogram we used to code teaching. Slowing down was operationally defined as the change in caregiver's duration of making one origami with and without a motivation to teach. To code this measure, coders watched the videos on the Datavyu Program (Datavyu Team, 2014) and identified the beginning and ending time of the phases. Both Phase 2 and Phase 3 began when the caregiver touched the origami paper in front of them. We ended the phases based on the following three indications on a case-by-case basis: caregiver (a) puts their pen down (pen was provided to draw the face), (b) puts the origami away, (3) touches a new origami paper. Duration of a phase

[1] While these caregivers were diverse and more distantly related to the child participant, and therefore may be argued to have less or more variable investment in the child's learning, omitting these five individuals from the analyses did not qualitatively change the results.

was calculated by subtracting the beginning time from the ending time. To establish reliability on phase durations, the second author trained a research assistant (RA1) how to make decisions for the beginning and ending times of the phases. RA1 independently coded 14 randomly selected cases (22% of the data). We calculated two sets of slowing down scores as described above and examined the agreement between coders with a series of two-way mixed, absolute, single measures intraclass correlations (ICCs). The ICC for this measure was .93, again indicating excellent agreement (Cicchetti, 1994).

Visual attention was measured during Phase 3 and was operationally defined as a look towards the direction of the child's origami or the child's face (see Table 1). To code this behavior, we used an interval coding strategy. The duration of Phase 3 was divided into 3-second intervals using the ELAN (2021) program and each interval was coded for the presence (a code of 1) or absence (a code of 0) of a look indicated by an eye movement or a head turn. If for a certain interval, the coder was not able to make a judgement due to poor lighting or the angle of the camera, that interval was given a code of 2 and excluded from the total duration. The final variable was calculated by dividing the number of intervals where the caregiver received a code of 1 divided by the total number of intervals. The final variable was a relative score of how much the caregiver visually attended to the child during the teaching phase. To examine reliability, a second research assistant (RA2) was trained in the visual coding system and independently coded a new set of 14 randomly selected cases (22% of the data). We calculated two sets of visual attention scores as described above and examined the agreement between coders with a series of two-way mixed, absolute, single measures ICCs. The ICC for this measure was .98, indicating excellent agreement (Cicchetti, 1994).

Pedagogical behaviors (see Table 1) were coded during Phase 3. We coded the occurrence of nine distinct behaviors: (1) pointing (with finger), (2) pointing (with face), (3) touching the child, (4) giving positive feedback, (5) giving negative feedback, (6) waiting, (7) repeating, (8) expediting, and (9) use of speech. Additionally, we also had a social gestures code where the caregiver used symbolic communication that was not relevant to the making of the origami (e.g., a gesture demanding silence). However, this variable was dropped from the final list of behaviors (see the Results section). To code these final nine behaviors, we used an event coding strategy where coders first needed to detect the occurrence of a pedagogical behavior, then to cross-classify that behavior into one of the 10 categories. This coding system produced frequencies. To accommodate for varied Phase 3 durations, we computed a rate score for each behavioral category by dividing the number of behaviors observed in a certain category by the dyad's Phase 3 duration in minutes. The final variable reflected the number of times this behavior was observed per minute.

To establish interrater reliability for the pedagogical behaviors, RA1 was trained in this coding system and independently coded 14 cases (22% of the data)—the same set of cases that were used for the reliability of phase durations. We compared agreement between coders using a number of reliability indices. Based on Bakeman and Gottman's (1987) recommendations for calculating reliability for cross-classification of events, as a first step, we examined the percentage of agreement for the occurrences and then calculated a kappa score for those events that were detected by both coders. The percentage agreement was .70, which we considered acceptable for a complex coding system. Moreover, after coding each case, coders watched together all of the events that were detected by only one coder and concluded that the missed events were not a result of systematic difference in coding decisions. In the second step, we used the events that were detected by both coders to examine whether coders reliably classified the detected events into the 10 behavioral categories we created. The kappa score was .87, indicating excellent reliability. To finalize the database, coders watched together the instances that were captured by only one coder in the first step of the reliability and made final decisions about whether or not to include these occurrences in the database. Next, the coders made together decisions to assign the newly included occurrences into one of the 10 behavioral categories. This was also repeated for all the discrepancies that arose during the second step of the reliability coding. Once the database was finalized, we created two summary scores in a way that are similar to those used in analyses presented in the results section. Precisely, we summed the scores obtained for touching, finger and head pointing, positive and negative feedback, expediting, and verbal as one aggregate variable and those obtained from waiting and repeating as another aggregate variable. Then, we examined the agreement between coders for the summed scores with a series of two-way mixed, absolute, single measures ICCs. The ICC scores were very high; .98 for the first and .98 for the second aggregate variable. Overall, our examination of the reliability for this coding system suggested that the coding system detected events consistently across dyads despite having missed some of the occurrences and that those events could be reliably categorized into different behavioral categories.

Finally, we also examined the diversity of teaching behaviors caregivers used during the test phase of the origami task. To examine this relationship, we created a diversity index as follows: For each of the teaching behaviors above (i.e., excluding slowing down and visual attention), each dyad was assigned either a 1 if the caretaker used the behavior one or more times during the observation period and a 0 if the behavior was not observed. Then, for slows down and

visual attention, the dyad was given a 1 if the behavior was observed at a rate greater than the mean. These counts were then summed across each variable. Thus, a higher score in this index reflected greater general diversity of the pedagogical behaviors observed as well as a greater tendency to slow down or to visually attend to the child as additional pedagogical strategies.

Results

To investigate whether the coded teaching behaviors were elements of different teaching styles (e.g., Clegg et al., 2021), we used the Bayesian exploratory factor analysis (BEFA) method from Conti and colleagues (2014) as implemented in the R package BayesFM (Piatek, 2021). This method does not require that an assumed number of factors is specified before the model sees the data. Rather, the most probable number of factors is inferred alongside other parameters (Conti et al., 2014). Thus, simultaneously, the method produces probabilistic estimates of the number of dimensions of the factor model, the assignment of measures to factors, and the factor loadings. The results of this analysis were then used to decide on the most appropriate variables to include as outcome variables in a Bayesian regression analysis of formal schooling experience on teaching behavior.

For the BEFA, no maximum number of factors was specified, and Markov Chain Monte Carlo (MCMC) sampling of posterior estimates of model parameters was iterated 4,000 times with a 1,000-iteration burn-in. The posterior frequency of the number of latent factors estimated by the model given the data was 69.80% for two factors, and 29.10% for three factors. Thus, a two-factor structure to the teaching behaviors is most probable based on these data. Figure 2a shows the mean posterior probabilities that each variable was assigned to one of the two "active" (at least three parameters load on the factor) latent factors, and in Fig. 2b, the mean posterior estimate of the factor loadings. As can be seen, *social* was not reliably assigned to a factor and was dropped by the model. As for the other variables, *expediting* had the highest correlation with underlying factor among the variables assigned to Factor 1, as well as *pointing with finger*, which had a moderately high factor loading. The other variables assigned to Factor 1 have relatively low posterior mean loadings (i.e., explain little of the variance in the factor), but high posterior mean probabilities of being elements of this latent factor. Factor 2 consists of *slows down*, which has by far the highest loading, *waits*, *repeats*, and *visually attends*. See Fig. 2a and b.

Qualitatively, these factors reflect a more involved, structured teaching style with feedback, verbal input, and gestures (Factor 1) and a less involved style in which the caregiver goes slowly, repeats steps, and waits for the child to imitate the model (Factor 2). Quantitatively, these two factors are moderately highly correlated, with a mean posterior estimated correlation of 0.51. Thus, each may still reflect a general stance towards teaching. However, given prior research on the contrasting styles of teaching associated with formal schooling versus intent participation learning contexts reviewed above, we reasoned these two factors reflect two plausible latent constructs which could be used as separate outcome variables in a regression analysis. As *visual attention* and *slows down* have different units than the other variables, for regression analysis, all teaching variables were transformed to z scores and then two new aggregate variables–*High involvement teaching*, or *HIT*, and *Low involvement teaching* or *LIT*–were computed by summing the z scores for the teaching behaviors assigned to each latent factor in the BEFA. Descriptive statistics for all coded behaviors and these aggregate measures can be seen in Table 2.

Regression models

Our hypotheses were tested using Bayesian regression analysis implemented in the R package *brms* (Bürkner, 2018). Cases with missing values for any of the covariates were removed and each continuous covariate was z scored before running the models. For the regression models, outcome variables included the latent variables derived from the BEFA results as well as the *diversity index*. The primary predictor variable was *caregiver's years of formal schooling*. Additionally, several covariates were included in the models which we reasoned could potentially mask the independent association of caregiver education on teaching style. First, *children's years of schooling* was included based on the rationale that those with more formal schooling might be more receptive to teaching or have more experience with analogous abstract learning tasks and therefore need less teaching such that caregivers may provide them less, independent of caregivers' own educational experience. Also, both *caregiver's* and *child's age in years* were included in the models, as older children may learn better than younger children and require less teaching; and, for parents, age may influence motivation or ability to teach. Additionally, *dyad–sex* was included to account for possible influences of sex on the probability of teaching or being taught. For

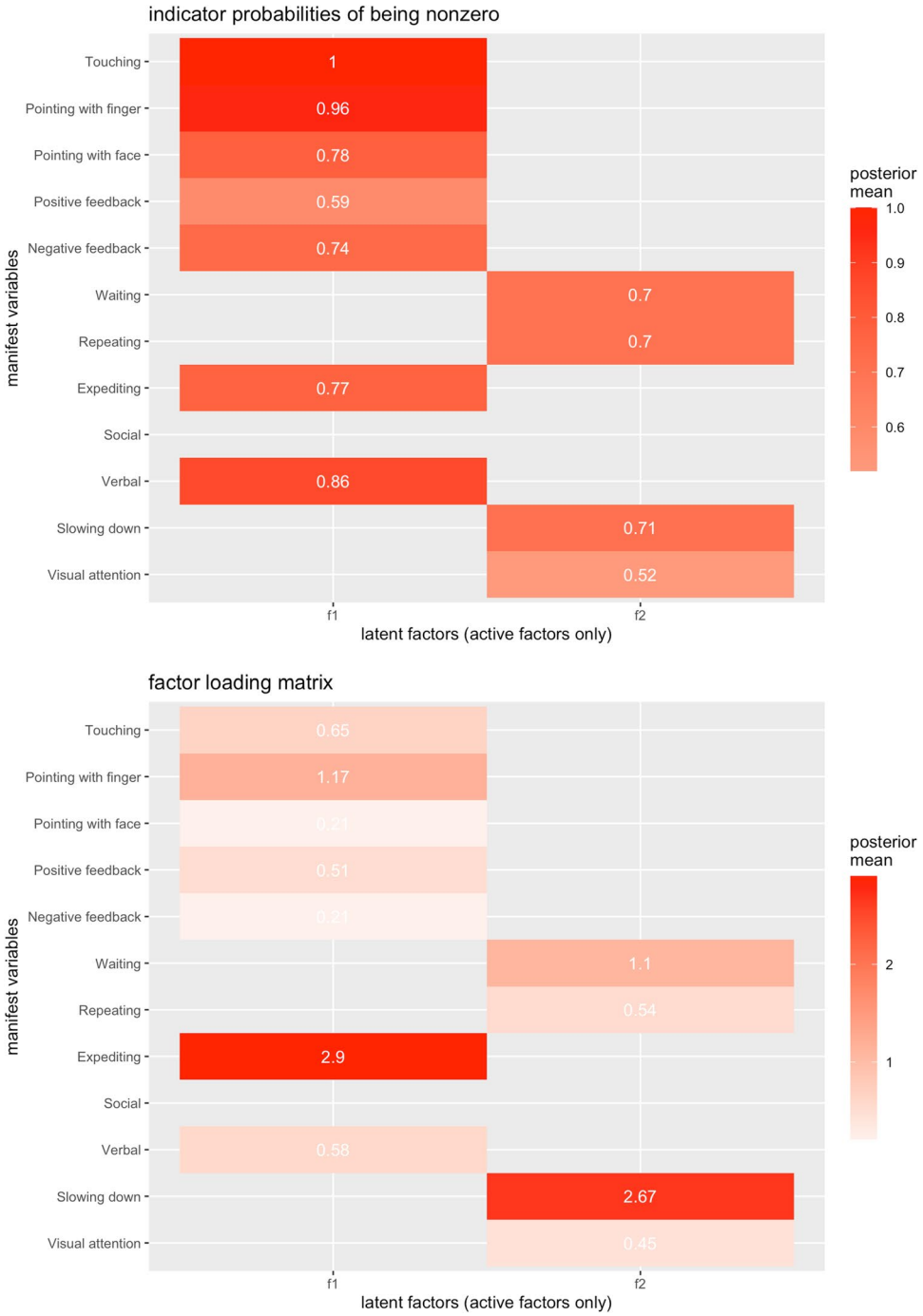

Fig. 2 **a** Posterior mean probabilities from a Bayesian exploratory factor analysis. These indicate relatively high probability of a two-factor solution composed of the individual variables as shown based on the data. "Active factors" are those on which at least three variables consistently load across each MCMC iterations of the model. Factor loadings (**b**) from a Bayesian exploratory factor analysis. These indicate relatively high probability of a two-factor solution composed of the individual variables as shown based on the data. "Active factors" are those on which at least three variables consistently load across each MCMC iteration of the model

example, woman have been observed to teach more frequently in some naturalistic contexts (Boyette & Hewlett, 2017). Lastly, *village type* (traditional versus kastom) was included in the model as an independent predictor to explore if kastom beliefs predict teaching style. We also entered an interaction term between *village type* and *caregiver's years of education* to test for the possibility that cultural beliefs and values augment or diminish the effect of caregiver's

Table 2 Descriptive statistics

Statistic	*N*	Mean	*SD*	Min	Pctl(25)	Pctl(75)	Max
Caregiver age (years)	64	36.03	10.44	19.00	29.80	42.00	70.00
Child age (kastom; years)	31	7.54	0.96	6.00	7.00	8.00	10.00
Child age (traditional; years)	32	7.13	0.74	5.69	6.71	7.58	8.53
Caregiver education (kastom; years)	31	0.58	8.85	0.00	0.00	0.00	5.00
Caregiver education (traditional; years)	33	6.33	11.84	0.00	6.00	8.00	13.00
Child education (kastom; years)	27	0.33	0.68	0.00	0.00	0.00	2.00
Child education (traditional; years)	33	1.49	0.57	1.00	1.00	2.00	3.00
Slows down	64	2.39	1.57	0.51	1.26	2.84	8.29
Seeks visual attention	62	0.59	0.31	0	0.30	0.86	1.00
Touches child	64	0.47	0.72	0	0	0.70	3.00
Points with finger	64	0.88	1.08	0	0.00	1.39	4.37
Points with face	64	0.16	0.30	0	0	0.30	2.00
Gives positive feedback	64	0.41	0.68	0	0	0.60	3.00
Gives negative feedback	64	0.16	0.36	0	0	0.10	2.00
Waits for child	64	1.07	0.97	0	0.00	1.72	3.31
Repeats action	64	0.45	0.60	0	0	0.70	3.00
Expediting	64	2.35	1.90	0	1.06	3.76	8.70
Social interaction	64	0.24	0.59	0	0	0.30	4.00
Verbalizes	64	0.60	0.95	0	0	0.90	4.00
HIT	64	0.0005	4.30	−4.92	−3.33	2.22	15.87
LIT	62	0.03	2.94	−4.61	−2.36	1.96	6.81
Diversity Index	57	5.33	2.88	0.00	3.00	8.00	11.00

Total sample included 64 dyads (54% female), with 33 from Traditional and 31 from kastom villages. Sample sizes vary because of missing data in some cases

formal schooling experience on teaching behavior, rather than their having a direct, independent effect.

Models were run predicting *HIT*, *LIT*, and *diversity index* of the form:

$$\begin{aligned} &\textit{Teaching} = \textit{Caregiver education z score} \\ &+\textit{Child education z score} + \textit{Caregiver age z score} \\ &+\textit{Child age z score} + \textit{Village type} + \textit{Dyad Sex} \\ &+\textit{Caregiver education z score} \times \textit{Village type} \end{aligned}$$

For the HIT model, *caregiver's education* predicted an increase in high involvement teaching, as hypothesized, although the probability density does include zero at the far low end (Beta = 0.99, 95% CI [−0.01, 2.02]). Being from a kastom village had an independent negative effect that was larger than education, with the far high end of the probability density again including zero (Beta = −1.21, 95% CI [−2.86, 0.46]). Additionally, child's education decreased caregiver's use of high involvement teaching (Beta = −0.62, 95% CI [−1.57, 0.35]), while high involvement teaching was also less probable among male dyads, with the probability estimate entirely below zero (Beta = −1.53, 95% CI [−2.85, −0.14]). Including the interaction in the model did not qualitatively change the results of the model, and the effect of the interaction could not reasonably be distinguished from zero. Thus, there is no support for an interactive effect of *caregiver's education* and *village type* on *HIT*.

Surprisingly, the LIT model showed even stronger evidence than the HIT model for a positive association between *caregiver's education* (Beta = 1.35, 95% CI [0.51, 2.19]) and teaching, failing to support our second hypothesis. Moreover, the estimates provide a roughly equal degree of evidence for a negative relationship between living in a kastom village and teaching (Beta = −1.25, 95% CI [−2.74, 0.76]). Interestingly, the model predicted a relatively higher probability of LIT within male dyads (Beta = 0.72, 95% CI [−0.34, 1.77]). Moreover, the estimated intercept for this model also predicts a slightly higher amount of LIT for female dyads from traditional villages (i.e., the reference categories) when the other variables are held at their mean values (Beta = −1.01, 95% CI [−2.23, 0.23]). Similar to the model for HIT, including the interaction in the model did not appreciably change the qualitative results of the model from those without the interaction. The effects of the interaction cannot be reasonably distinguished from zero. Results of these regression models (excluding the interaction term) are plotted in Fig. 3.

For the *diversity index*, results were consistent with the patterns for both *LIT* and *HIT*. The regression model

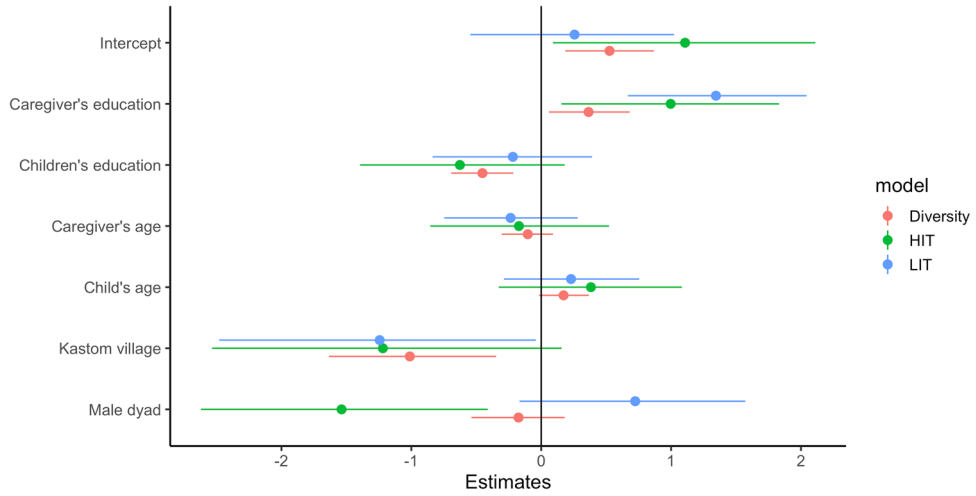

Fig. 3 Posterior predictive estimates from the Bayesian regression models predicting high-involvement teaching behaviors, low-involvement teaching behaviors, and teaching diversity (as measured by the computed *diversity index*; see text). The intervals around the point estimate are 95% intervals

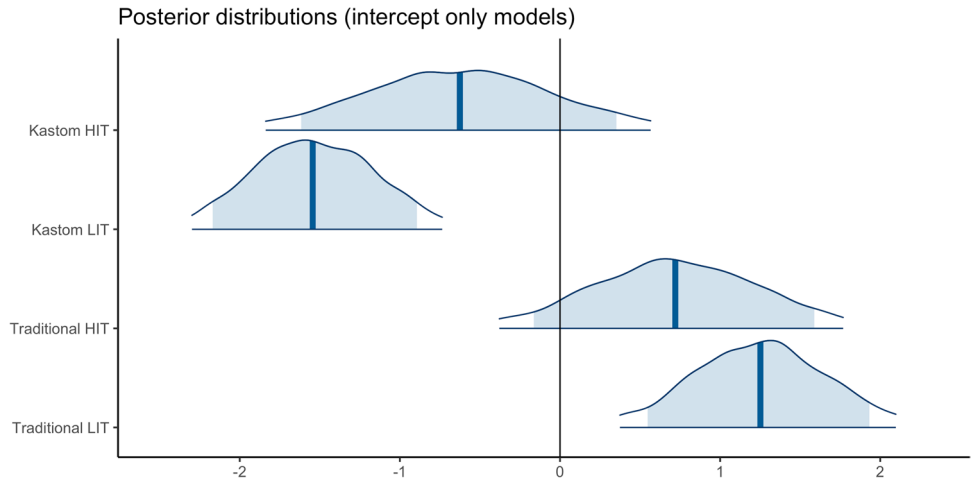

Fig. 4 Posterior distributions of estimates from intercept-only Bayesian regression models in which either kastom- or traditional-village type predicted high-involvement teaching (HIT), low-involvement teaching (LIT), or the *diversity index* (not shown). The blue vertical line is the median estimate, the shaded region under the curve the 89% probability mass, and the unshaded outer region the 95% probability mass. (Color figure online)

indicates that, based on the data, *caregiver's education* is associated with a greater *diversity index* (Beta = 1.25, 95% CI [0.36, 2.12]), in support of our third hypothesis. Additionally, dyads from traditional villages used a greater diversity of behaviors than kastom dyads ($t = 3.87$, $p < .001$, Welch two-sample *t* test). There is also high probability that *kastom village* is negatively associated with *diversity*, although 0 falls just within the 95% confidence intervals (Beta = −1.40, 95% CI [−2.99, 0.18]). Greater *child's education* also likely predicts a lower *diversity* of teaching behaviors used (Beta = −0.83, 95% CI [−1.59, 0.07]). The posterior predictive distributions are plotted alongside those of the other teaching metrics in Fig. 2.

The regression models we presented so far showed that being from a traditional village was associated with higher use of both *HIT* and *LIT* strategies compared with being from a kastom village. However, they did not indicate whether either group prioritized one strategy over the other. To examine this question, we estimated the probability distributions of *HIT* and *LIT* in an intercept only model in *brms* using flat priors, separately within each village type. The distribution of 4,000 parameter draws from the posterior distributions of these models are plotted in Fig. 4. The models

predict that traditional village dyads use both *HIT* and *LIT* more frequently than kastom villages, and neither group put an emphasis on either one strategy.

Discussion

The objective of this study was to identify and examine variation in teaching behaviors as they exist in two cultural communities within one society, that of Tanna Island, Vanuatu, that vary in their participation in formal, "Western-style" schooling. To do so, we examined the frequencies and diversity of teaching behaviors used by Tannese caregivers with their children as they made an origami figure together. While our results provided mixed support for our hypotheses, the evidence overall supports the view that there are commonalities to teaching across human cultures but also that sociocultural context strongly influences the nature of teaching within communities. As such, our results add to interdisciplinary discussions regarding cultural diversity in teaching and learning behavior (Boyette & Hewlett, 2017; Clegg et al., 2021; Kramer, 2021; Lancy, 2010; Paradise et al., 2014) and the role of teaching in cumulative cultural evolution (Burdett et al., 2018; Caldwell et al., 2018; Fogarty et al., 2011; Kline, 2015; Lancy, 2016). Over the past few decades, there have been several debates regarding the role of teaching in human evolution (Csibra & Gergely, 2011; Gergely & Csibra, 2006; Lancy, 2010; Tomasello et al., 1993). Some have claimed that humans evolved a social learning system, preceding the evolution of other complex cognitive architecture, and that it relies on the ability to detect and produce nonverbal pedagogical signals through behavioral cues. They claim that humans engage in teaching, often unaware, through slowing down and providing a range of specific communicative gestures (which may be culturally specific) in order to draw attention to the relevant features during a learning episode. Unlike other social learning strategies, such as imitation, teaching is thought to be unique as it enables complex cultural forms to be transmitted with high fidelity. In our work, we provide evidence for the existence of such nonverbal pedagogical behaviors in a diverse cultural context in which a large proportion of the population rejects formalized education. This is notable as one argument (see Lancy, 2010) against the claim for "natural pedagogy" recognizes that the argument rests on evidence from Western societies in which parenting is synonymous with teaching and there is a heavy reliance on formalized education. Other more recent work also found that "costly teaching" in which the teacher modifies their behavior at a cost (e.g., time) to facilitate learning in the novice was frequently used to transmit complex skills such as spear hunting amongst BaYaka forager adolescents (Lew-Levy et al., 2022).

First, our Bayesian regression analysis showed that, based on these data, there is clearly a greater probability that variation in teaching behavior is associated with caregiver's experience with formal, Western-style classroom education. In particular, in line with our first hypothesis, results indicated that caregivers who had greater experience with formal education used more high involvement teaching behaviors. However, contrary to our second hypothesis, caregivers with more education were also more likely to use low involvement teaching. Thus, education predicted more teaching behavior overall, rather than just a specific strategy. Additionally, in support of our third hypothesis, caregivers with more formal education also used a larger range of teaching behaviors. These results are in-line with prior work showing formal education to be positively associated with more frequent involvement in children's learning and a greater diversity of teaching behaviors used to help children learn (Clegg et al., 2021; Paradise et al., 2014). However, our results highlight the fact that the behavioral constituents of teaching strategies are not necessarily coupled to the sociocultural forces which promote or discourage teaching in general. In other words, while our Bayesian factor analysis approach did indicate that the data had a high probability of constituting two latent variables fitting these high involvement versus low involvement strategies (Fig. 2a and b), both of these latent variables had high probability of association with caregivers' years of education. We can only suggest at this point that Tannese caregivers might prefer one strategy to the other based on other, unmeasured individual differences, such as life experience, personality, and so on.

Given the rejection of Western education by Tannese followers of kastom beliefs, we explored whether and how such a worldview would affect teaching behavior independent of caregiver experience with formal schooling. Since we had some variation in education within each village type, we were able to test the independent effects of education and village type. Based on our analysis, both low and high involvement styles of teaching were negatively associated with being from these villages, as was the diversity of teaching behaviors (Fig. 3). Our models suggest that these effects were independent of caregiver's education. There was also no moderating relationship between village type and education that would suggest, for example, that normatively rejecting formal education would attenuate the amount of teaching among those participants from kastom villages who had relatively greater formal schooling experience than their peers. These results suggest that teaching in general is not a favored means of education in kastom communities, but we also examined whether there was a relative preference for low versus high involvement teaching among caregivers from kastom versus traditional villages. As can be seen in Fig. 4, based on these data, there was no clear evidence of a preferential teaching style within either village type. Thus,

our results suggest that caregivers from kastom villages, in this experimental paradigm where teaching was prompted, demonstrated a tendency towards avoidance of involvement in children's learning. While prior research showed a style of teaching more characteristic of the intent participation tradition in a tangram puzzle task among Tannese parents when compared with American parents with far greater exposure to formal education (Clegg et al., 2021), our results demonstrate that there is also further variation in teaching behavior within Tannese society—in particular, in relation to whether or not one comes from a community that has endorsed kastom as a movement against Christianization and Westernization, and associated cultural practices, including formal schooling as a means of education (Tonkinson, 1982).

Conclusion

The results of this study add to a growing base of evidence that there are commonalities across human population in how people teach, but also significant culturally driven variation. Perhaps most critically, given that caregivers that this study sampled from traditional villages reported only an average of 6 years of formal schooling and those from kastom villages only 0.5 years, these results illustrate the powerful effect of this particular educational tradition on the cultural evolution of teaching within human populations (Cole, 2005; Scribner & Cole, 1973). In this light, we interpret these results as further support for the idea that teaching behaviors which have been documented in societies with formal schooling as a predominant form of education may not be capturing the full range of behaviors, and, in fact, may be skewing our understanding of teaching and cumulative cultural evolution. To date, the large majority of studies examining theories of cultural evolution, and specifically natural pedagogy, have been conducted in societies with a heavy emphasis and experience with formalized schooling. This is a relatively recent development in the course of human existence, and therefore the behaviors documented in these societies are unlikely to reflect an evolved cognitive system as the authors of those studies propose.

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