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The development of children's teaching varies by cultural input: evidence from China and the U.S.

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Teaching, often seen as a natural cognitive ability, is also shaped by cultural environments. This study compared the teaching strategies among 146 3- to 7-year-old children (81 females) from the U.S. ($n = 52$, White) and China (traditional preschool $n = 49$, Asian; "westernized" preschool $n = 45$, Asian). Children taught a board game to learners with varying knowledge levels. We measured children's false belief and knowledge attribution and coded three teaching strategies: verbal, contrastive, and contingent. Results showed that children from traditional Chinese preschools were less likely to engage in verbal and contingent teaching than their U.S. and "westernized" Chinese counterparts. Knowledge attribution predicted teaching strategies across cultures. These findings underscore the influence of cultural input on teaching strategies.

KEYWORDS

culture, teaching, preschoolers, social transmission, cognitive development

Introduction

The ability to teach allows humans to transmit cultural knowledge and facilitates cumulative cultural learning (Csibra and Gergely, 2011; Dean et al., 2014). While substantial focus in both popular and scientific media has been directed toward children's development as learners, far less attention has been given to their development as teachers (e.g., Kline, 2015; Ronfard and Harris, 2018; Strauss and Ziv, 2012). While teaching is frequently regarded as a natural cognitive ability, demonstrated by children's spontaneous teaching without explicit instruction (Ronfard and Corriveau, 2016; Strauss et al., 2002; Ye et al., 2021), it is likely also shaped by their cultural environment (Brandl et al., 2023a). That is, although similar cognitive skills underpin children's ability to teach, the *manner in which* children teach—how they teach (their teaching style) and what they teach (the content of their teaching)—may vary across cultures (Kline, 2015; Lancy, 2010; Maynard, 2004; Paradise and Rogoff, 2009; Rogoff, 2003; Vygotsky, 1980). The present research addresses how cultural scripts shape children's developing teaching strategies beyond cognitive abilities. In doing so, we expand the limited body of research on this topic outside of Western cultures by testing young children in two cultures that differ markedly in their predominant pedagogical beliefs and practices: the United States and China (Tobin et al., 2009; Zhu and Zhang, 2008).

Teaching as a natural cognitive ability

Children's ability to teach emerges and develops rapidly during the preschool years (see [Strauss and Ziv, 2012](#), for a review). When preschoolers are asked to teach their peers the rules of a board game, their teaching styles transition from being primarily non-verbal at around 3- and 4-years of age to predominantly verbal instruction by the age of 5 (e.g., [Davis-Unger and Carlson, 2008](#); [Strauss et al., 2002](#)). By the age of 6, children understand teaching as a communicative process that begins with an epistemic gap between the teacher and the learner ([Sobel and Letourneau, 2016](#)). During the preschool years, children also become increasingly responsive to their learners' performance. They not only consider their learner's knowledge, goals, and competence, but also adjust their teaching based on their learners' knowledge states ([Baer and Friedman, 2018](#); [Bridgers et al., 2020](#); [Danovitch, 2020](#); [Davis-Unger and Carlson, 2008](#); [Gweon and Schulz, 2019](#); [Ronfard and Corriveau, 2016](#); [Qiu et al., 2024](#); [Strauss et al., 2002](#); [Wood et al., 1995](#); [Ziv et al., 2016](#), see also [Qiu et al., 2025](#) for a meta-analysis).

Teaching is considered a natural cognitive ability because children engage in spontaneous teaching without explicit instruction ([Strauss et al., 2002](#)). Theoretical accounts highlight the importance of inferring what learners understand in specific teaching contexts ([Strauss et al., 2002](#)) and suggest that the ability to apply mental state reasoning in these contexts is closely linked to children's teaching abilities ([Ashley and Tomasello, 1998](#); [Tomasello et al., 2005](#); [Wood et al., 1995](#)). In support of this interpretation, [Strauss et al. \(2002\)](#) documented a positive correlation between 3- to 5-year-old children's use of verbal instruction as a teaching strategy and theory-of-mind abilities. [Davis-Unger and Carlson \(2008\)](#) found that theory-of-mind abilities is related to both the amount of time 3- to 5-year-old children spent teaching and their use of multiple teaching strategies. [Ziv et al. \(2016\)](#) showed that theory-of-mind abilities is related to 3- to 5-year-old children's ability to adjust their teaching to a learner's response. Most recently, [Bass et al. \(2019\)](#) found that general ToM, as measured by the standard false belief task, was related to 3- and 4-year-old children's ability to optimally select pedagogical evidence. [Ronfard and Corriveau \(2016\)](#) conducted the first published study examining the relation between children's ability to infer teaching-specific mental states and their teaching ability. In that study, 3- to 5-year-old children observed the mistakes of a learner and were asked to make inferences about the learners' knowledge states. The results demonstrated that children who were more adept at inferring their learners' knowledge states from mistakes employed more advanced verbal teaching strategies, including making contrasts about what should and should not be done. Taken together, this empirical evidence supports theoretical accounts pointing to the importance of representing mental states for teaching ([Corriveau et al., 2018](#)).

Teaching as a cultural practice

Humans exhibit numerous cross-cultural differences in both the content and methods of teaching (see [Brandl et al., 2023b](#), for a review). However, the empirical studies on children's

teaching reviewed above have predominantly been conducted in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies ([Henrich et al., 2010](#)). These studies suggest that children in WEIRD cultures increasingly develop into teachers whose instruction is learner-centered and tailored to their learners' specific mistakes. Nonetheless, considerable variability exists in the way parents and communities "teach" young children ([Lancy, 2010](#); [Maynard, 2004](#); [Rogoff, 2003](#)). In some cultures, adults employ pedagogical cues to guide learners' attention, while in others, learning is expected to occur through observation and active participation ([Csibra and Gergely, 2011](#); [Paradise and Rogoff, 2009](#); [Lancy, 2010](#)). These diverse cultural practices are adapted to children's local environment, shaping how children learn from those around them and potentially influencing their own teaching practices ([Shneidman et al., 2015](#)).

Some research has shown cultural differences in children's teaching behaviors. Evidence from [Kim et al. \(2018\)](#) suggests differences in 6-year-old Japanese and German children's choice of learners. When asked to choose between teaching an ignorant or knowledgeable learner, Japanese children were more likely than their German peers to choose to teach the ignorant learner. The researchers suggested that the collectivistic culture in Japan, which emphasizes relationships and interdependence, may influence children to view teaching as fulfilling others' needs. Although the study focused on whom children chose to teach rather than their actual teaching behavior, the findings suggest that conclusions drawn from studies in Western cultures on teaching development may not generalize to non-Western cultures. In response to the debate between cognitive and cultural inputs of children's teaching abilities, [Ye et al. \(2021\)](#) investigated the relation between children's mental state inference and teaching ability in Singapore. In a task where 4- to 6-year-old children taught learners who made different mistakes, children with enhanced abilities to infer their learners' knowledge states and had better theory-of-mind abilities were more likely to use elaborative teaching strategies by explaining the reasons behind the rules of the game. Although these findings suggest that links between mental state abilities and children's teaching are not exclusive to WEIRD cultures, the study did not explore specific cultural factors that may explain possible differences in children's teaching.

Taken together, existing research indicates that cultural scripts influence children's teaching behaviors. However, our understanding of how culture shapes these behaviors remains limited. One way in which children's teaching behaviors vary across cultures is through the pedagogical beliefs and practices they encounter in school environments. These pedagogical approaches—whether learner-centered or teacher-directed—directly shape how children understand and engage in the teaching process. For example, children in learner-centered environments, where teaching is interactive and adjusts to individual learners' needs, may develop teaching behaviors that emphasize verbal explanation, and respond to their learner's specific mistakes. In contrast, children in more traditional, teacher-directed settings, where instruction is often top-down and more rigid, may adopt less interactive, more directive teaching methods. On this hypothesis, exposure to pedagogical beliefs and practices is likely to not only influence children's understanding of how to teach but also

the specific strategies they employ when teaching others (e.g., LeVine et al., 2011; Visscher, 2010). Given that much of research on the influence of cultural scripts on children's teaching have only compared between cultures, our understanding of potential within-culture variation is limited.

The present study

The current study aims to explore cultural differences in children's teaching strategies by comparing young children in the United States and China, two countries with documented differences in pedagogical beliefs and practices historically. Additionally, within the Chinese sample, it contrasts children attending a traditional Chinese preschool to those in a "westernized" Chinese preschool that adheres to Western-style pedagogy. Differences in U.S. and traditional Chinese parental beliefs and practices surrounding the role of teachers in preschools have been well documented. In Western societies, independence, self-expression, and autonomy are highly valued, leading European American parents and educators to prioritize preschools that foster these skills (Kim, 2002; Rothbaum et al., 2000; Tobin et al., 2009, 1989). This is evident in their emphasis on flexible, learner-centered pedagogies that address individual needs and encourage creativity, often through play, to encourage self-exploration and enhance cognitive development (Flavell, 1963; Johnston and Wong, 2002; Parmar et al., 2004). On the other hand, traditional Chinese parents often consider individualism and self-expression undesirable traits at an early age (Rothbaum et al., 2000). Instead, they prioritize high educational achievement and believe in the benefits of attending preschool for a head start in academic work (Pang and Richey, 2007; Sun and Rao, 2017). Traditional Chinese parents prioritize teacher-directed instruction and view play as a distraction from learning (Farver et al., 1995; Li et al., 2010; Stevenson and Stigler, 1992). They believe that children learn most effectively under the guidance of skilled teachers in a structured environment (Baruth and Manning, 1992). When asked what constitutes a high-quality preschool, Chinese immigrant parents emphasized the quality of teachers while European American parents highlighted the importance of individualized attention in preschools (Yamamoto and Li, 2012).

One limitation of previous research is that cultural differences in children's teaching behaviors is rarely explored. Even in studies that have attempted to address this issue (e.g., Ye et al., 2021), no specific cultural factors were identified that could explain potential differences in children's teaching. To address this gap in the literature, our study focused on the influence of teachers' pedagogical beliefs and practices in the U.S. and China on children's teaching strategies. In line with the documented variability in pedagogical beliefs, the traditional instructional practices in China and the U.S. are also distinct (Sun and Rao, 2017; Tobin et al., 2009). Traditional Chinese teaching and learning emphasizes training and knowledge acquisition through memorization, student effort, teacher authority, and discipline (Rao et al., 2003). As a result, traditional preschool education in China is academically orientated and teacher-directed, emphasizing knowledge and skill acquisition rather than initiative and creativity (Liu and Elicker,

2005). Traditional Chinese teachers exhibit high control, stress obedience and order, and usually lecture or demonstrate concepts to groups of children in accordance with instructions rather than engaging in individualized instruction with each child (Paine, 1990; Pang and Richey, 2007). In contrast, many preschool and elementary school classrooms in the U.S. are play-oriented and learner-centered, which allows for more individualized attention (Pang and Richey, 2007). Preschool teachers in the U.S. encourage exploration in children by using an inquiry-based instruction approach, emphasizing children's understanding of the processes behind a concept rather than focusing on mastering the concept (Qi, 2022).

We also investigated within-cultural differences among the Chinese preschool samples, considering the Chinese government's advocacy for educational reforms in preschools and guidelines that promote learner-centered curricula. For example, the New Curriculum Reform in China promotes learning through teacher-student interactions, encouraging teachers to pose questions and adapt their strategies based on students' responses to foster deeper learning (Ministry of Education, 2001). Despite two decades of advocating learner-centered beliefs, research indicates these ideas are often seen as "borrowed" from the West and remain challenging to implement (Tan, 2016; You, 2018). Content-based knowledge transmission and strong teacher authority still dominate most classrooms (You, 2018). As such, the adoption of these "Western" pedagogical practices has been inconsistent, with some Chinese preschools fully embracing Western-style pedagogy, others adhering to traditional approaches, and some attempting to integrate both approaches (Sun and Rao, 2017; Tobin et al., 2009; Zhu and Zhang, 2008). Therefore, our full sample included children from a traditional Chinese preschool, a learner-centered preschool and museum setting in the U.S., as well as a Chinese preschool endorsing Western-style pedagogy. This approach enabled us to examine how differences in children's exposure to various teaching styles and teachers' pedagogical beliefs shape their own teaching strategies, taking into account both intra-cultural variability based on children's local environment (i.e., their preschool) and inter-cultural variability between the broader cultural contexts of the U.S. and China.

In the present study, 3- to 7-year-old children from the U.S. and China were asked to teach a board game adapted from Ronfard and Corriveau (2016) to learners who differed in their knowledge states. As in Ronfard and Corriveau (2016), children interacted with puppets rather than people during the task to maximize experimenter control. We assessed children's teaching strategies by examining their teaching style and teaching content. Teaching style was assessed in two ways: whether children engaged in verbal teaching and contrastive teaching (i.e., whether they compared what the learner should and should not have done). Teaching content was assessed by examining children's ability to adjust their teaching specifically to the mistakes made by the learners. We were primarily interested in determining whether cross-cultural differences in children's teaching strategies result from unique culture-specific experiences. This involved examining whether children's teaching strategies differed among the U.S., traditional Chinese, and "westernized" Chinese preschool settings, as well as studying the links between children's teaching strategies

and the primary pedagogical beliefs and practices to which they are exposed. Specifically, teachers' pedagogical beliefs and practices from the three cultural settings were assessed using the Teacher Belief Scale and the Instructional Activities Scale (Charlesworth et al., 1991).

Our secondary aim was to investigate whether differences in children's teaching strategies across cultural settings is related to the development of mental state reasoning. We measured children's mental state reasoning with the standard false belief unexpected contents task (Wellman and Liu, 2004) and their ability to attribute knowledge to learners accurately based on past literature (Corriveau et al., 2018; Ronfard and Corriveau, 2016; Ye et al., 2021).

To summarize, we examined whether differences in children's teaching strategies is a product of unique culture-specific experience. We also investigated links between children's teaching strategies and their understanding of mental states. We hypothesized that the main pedagogical beliefs and practices to which children are exposed would shape the development of their teaching strategies. Specifically, children exposed to a learner-centered pedagogy (i.e., U.S. children and Chinese children attending a "westernized" Chinese preschool) were expected to engage in more verbal teaching, contrast what the learner should and should not have done, and adopt a more learner-centered teaching approach by adjusting their teaching based the learner's knowledge state. These teaching strategies prioritize learner-centered engagement and comprehension over rigid, top-down teacher-directed instruction. For instance, contrastive teaching directly addresses misconceptions, making learning more interactive and reflective of the learner's needs. In contingent teaching, adapting instructions to the learner's specific mistakes fosters individualized learning and self-correction. Conversely, children exposed to a teacher-directed pedagogy (i.e., Chinese children attending a traditional preschool) were expected to engage less in verbal teaching, be less likely to contrast learner actions, and follow a more teacher-directed approach, making fewer adjustments based on the learner's specific mistakes. Based on previous studies (e.g., Bass et al., 2019; Davis-Unger and Carlson, 2008; Ronfard and Corriveau, 2016; Strauss et al., 2002; Ye et al., 2021; Ziv et al., 2016), we also expected that false belief understanding, as well as the ability to attribute knowledge to learners, would be linked with children's teaching strategies irrespective of cultural input.

Method

Participants

One hundred and forty-six children aged 3–7 participated in this study. The sample included 52 English-speaking U.S. children (32 girls, $M = 5.4$, $SD = 1$ year) and 94 Mandarin-speaking Chinese children (49 girls, $M = 5.5$, $SD = 1$ year). Previous research indicates an age-related shift in children's teaching behaviors at the age of 5 (e.g., Davis-Unger and Carlson, 2008; Ziv et al., 2016), as well as a development of their understanding of false belief (Wellman et al., 2006). As such, for the purposes of data analysis, we

split our three samples in the U.S. and China into a younger (range from 3.4 to 5. U.S.: $M = 4.5$, $SD = 5$ months. $N = 27$; traditional Chinese: $M = 4.6$, $SD = 5$ months. $N = 25$; "westernized" Chinese: $M = 4.6$, $SD = 5$ months. $N = 25$) and an older age group (range from 5.6 to 7.9. U.S.: $M = 6.3$, $SD = 6$ months. $N = 25$; traditional Chinese: $M = 6.4$, $SD = 5$ months. $N = 24$; "westernized" Chinese: $M = 6$, $SD = 5$ months. $N = 20$). Sample sizes are consistent with the results of a power analysis and previous research using similar procedures. The minimum sample size parameter was 20 children in each cultural setting per age group based on an estimation in G*Power using an effect size of $d = 0.17$ (Ronfard and Corriveau, 2016), $\alpha = 0.05$ and $\beta = 0.95$.

The U.S. children were recruited from a local preschool and a science museum in a large Northeastern city, from June 2015 to January 2016. Instruction in both these settings is learner-centered, with most activities focused on small groups engaging in play-based activities. At the time of data collection, the teacher student ratio was 1:6 in the preschool at the time of data collection. Although information about socioeconomic status and ethnicity was not collected for individual participants due to museum and preschool regulations, demographic information from the museum and preschool records showed that both the preschool and the museum primarily serve middle and upper-middle class European-American families (Soren, 2009). Preliminary analyses indicated that children did not differ in their use of teaching strategies or mental state reasoning abilities across settings.

The Chinese children were recruited from two local preschools in the urban areas of Beijing, China. Data from the traditional Chinese sample collected in the summer of 2015 from a preschool with traditional teaching practices, with a curriculum that emphasized the learning and mastery of math, language, and art content. At the time of data collection, the teacher student ratio was 1:7. Data from the "westernized" Chinese sample was collected between April and June 2017 from a preschool that promoted "westernized" teaching practices, with a teacher student ratio of 1:7. Although specific information about children's socioeconomic status was not collected, records from the preschools indicate that the two Chinese preschools primarily serve families from middle and upper-middle class backgrounds.

Materials and procedure

The experiment was conducted in English for the U.S. children and Mandarin for the Chinese children. To ensure testing fidelity across cultural sites, the study protocol was translated and back-translated by two bilingual speakers. Children completed two tasks in a fixed order: a teaching task and an unexpected contents false belief task. To confirm anticipated differences in the pedagogical beliefs and practices of the three cultural settings, teachers from the U.S. ($N = 2$), traditional Chinese ($N = 3$), and "westernized" Chinese preschool classroom ($N = 3$) from which the children were sampled completed the Teacher Belief Scale and the Instructional Activities Scale (Charlesworth et al., 1991).

Teaching task

The teaching task was adapted from [Ronfard and Corriveau \(2016\)](#). There were two phases: a learning and a teaching phase. In the learning phase, children learned to play a board game. In the teaching phase, children first watched three puppet learners play the game before rating each learner's knowledge (i.e., knowledge attribution) and teach those learners who made mistakes to play the game (i.e., teaching strategies).

Learning phase

The main goal of the learning phase was to introduce the rules of a board game and for children to observe three learners play the game before teaching them. The board game involved a small magnetic whiteboard with a red square drawn on it and two 0.5-inch × 0.5-inch square wooden pieces: one painted black (non-magnetic) and the other painted red (containing a non-visible magnet). After the child participants correctly identified the colors of the two square pieces, the experimenter taught them the game rule: to place the red square piece, and not the black square piece, inside the red square drawn on the whiteboard. Children were then invited to play with the pieces. To check for children's understanding of the game rules, they were asked two questions: (1) Where do you have to put the pieces in the game? (2) What pieces do you need to use in the game? All children correctly answered both questions.

Teaching phase

Children's teaching ability and knowledge attribution was observed and coded in the teaching phase. Following the learning phase, children observed three gender-matched learners, who made different mistakes, play the board game. The experimenter introduced the learners by saying, "OK, now we are going to watch some puppets play the game. Let's pretend they are real people. They played the game before, but they might make some mistakes, so pay close attention." Each learner greeted the child by saying, "Hi, my name is Alex/Jamie/Casey (Chinese sample: BaoBao/BeiBei/HuanHuan) and I'm going to play the game." One learner made a single mistake (i.e., placed the incorrect piece in the correct location), another made two mistakes (i.e., placed the incorrect piece in the incorrect location), and the third learner made no mistakes (i.e., played the game correctly). The order of presentation of the three learners was counterbalanced and their names differed between testing locations to ensure familiarity and cultural appropriateness.

Knowledge attribution

After watching each learner play, children were asked two questions probing their inferences about the learner's understanding of the game based on their behavior: (1) Do you think [learner's name] played the game correctly? (2) Does [learner's name] understand not that much, some things, or everything about the game? We adopted the second question as the target question to test for children's knowledge attribution. We compared children's ratings of the three learners in pairs: zero-mistake vs. one-mistake, zero-mistake vs. two-mistakes, one-mistake vs. two-mistakes. Children received a score of 1 each time they rated the knowledge of the learner with fewer mistakes as higher than the

learner who made more mistakes. Scores were summed to create a final score that ranged from 0 to 3.

Teaching strategies

All children were then invited to teach the two learners who made mistakes so that they "could play the game better." Children were not asked to teach the third learner who made no mistakes. Verbal and non-verbal responses were recorded and coded for children's teaching style and teaching content.

False belief task

Children's false belief understanding was assessed using the standard unexpected-contents false belief task. The English version was adapted from [Wellman and Liu \(2004\)](#), while the Mandarin version was adapted from [Wellman et al. \(2006\)](#). Children received a score of 1 if they passed both the control and target questions.

Coding of children's teaching

We first coded for the specific teaching styles children used when teaching the two learners who made mistakes. Second, we coded for children's teaching content, i.e., the extent to which children attended to the specific needs of the two learners who made mistakes. Children received a point for each instance of teaching with each ignorant learner for each trial (two trials in total). The same scoring system was used for non-verbal teaching, verbal teaching, contrastive teaching, and contingent teaching.

Teaching styles

Non-verbal teaching

To explore children's teaching styles, we coded for the presence of *non-verbal teaching*, such as physically demonstrating how to play the game.

Verbal teaching

We also coded for *verbal teaching*, where children would verbally explain how to play the game, for example, "Use the red one and put inside the square".

Contrastive teaching

If children were coded as having engaged in verbal teaching, their teaching was further assessed for the presence of *contrastive teaching*, which involves comparing what the learner should have and should not have done (e.g., "Do not use the black piece. Use the red one and put it here."). Thus, while all children who used contrastive teaching also engaged in verbal teaching, not all children who engaged in verbal teaching used contrastive teaching. Furthermore, children who used contrastive teaching were viewed as behaving more consistently with a learner-centered approach while those who do not were viewed as following a more teacher-directed, didactic approach. The first author and a research assistant blind to the hypotheses, children's age, knowledge attribution, and false belief score, coded all the teaching styles. Agreement was 99% ($\kappa = 0.96$). Any disagreements were resolved through discussion.

Teaching content

To examine the extent to which children's teaching content was attuned to the specific needs of learners, we coded for how much information children transmitted to the two learners who made different mistakes.

Contingent teaching

For each trial, children's teaching content was coded as *contingent* if the information they provided to each learner was specific to the learner's unique mistakes. Children's teaching content was coded as *not contingent* if the information children provided was not clearly related to either learners' specific mistakes, such as teaching the wrong piece of information or two pieces of information to the one-mistake learner. Other examples include teaching only one piece of information to the two-mistake learner, teaching only through demonstration without tailoring their instructions specifically to each learner. We viewed the contingent teaching as most consistent with a learner-centered practice, whereas the non-contingent teaching as most consistent with more of a teacher-directed, didactic approach. The first author and a research assistant blind to the hypotheses, as well as children's age, knowledge attribution, and false belief score, coded children's teaching for the two learners, and reached an agreement of 98% ($\kappa = 0.96$). Any disagreements were resolved through discussion.

Teachers' pedagogical beliefs and practices

To confirm anticipated differences in the pedagogical *beliefs* and *practices* of the three samples, teachers from the U.S. preschool classroom, traditional Chinese preschool classroom, and "westernized" Chinese preschool classroom completed the Teacher Belief Scale and the Instructional Activities Scale (Charlesworth et al., 1991). These two scales were originally used to measure preschool teachers' belief about, and engagement in developmentally appropriate practices (DAP), and were chosen because they include items that measure the degree to which teachers endorse and practice learner-centered as opposed to teacher-directed pedagogy (see Table 1 for specific questions included in our analysis). Other items in the scale were used as distractors to conceal the purpose of the survey. The Teacher Belief Scale asks teachers to rate the importance of various pedagogical beliefs on a 5-point scale from "Not at all Important" to "Extremely Important." The Instructional Activity Scale asks teachers to indicate how often children in their setting participate in pedagogical activities on a 5-point scale from "Almost Never" to "Very Often."

Results

Preliminary analyses indicated no differences by gender. We first explored cultural variability and age-related changes in children's teaching strategies. Next, we investigated cultural variability and age-related changes in children's knowledge attribution ability and false belief understanding (i.e., mental state reasoning abilities). We then examined the role of children's mental state reasoning abilities on their teaching strategies beyond cultural differences. Lastly, we reported the pedagogical beliefs and practices

of teachers across the U.S., traditional Chinese, and "westernized" Chinese preschool settings.

Cultural variability in children's teaching strategies

Teaching styles

Table 2 displays the proportion of trials in which children engaged in each of the three teaching styles by Age Group and Cultural Setting. Inspection of Table 2 reveals that nearly all children engaged in *non-verbal teaching*; therefore, no further analyses were conducted. Further examination of Table 2 shows age differences and cultural variation in children's *verbal teaching* and *contrastive teaching*.

To explore these patterns, we initially ran a series of mixed-effects binomial logistic regression analyses with the *glmer* function of the *lme4* package in R on the likelihood that children engaged in a specific teaching style. However, due to poor fitting of these models, we opted to conduct the analyses using general linear models on the repeated binomial trial data with the *glm* function in R. The models included Age Group (Younger, Older), Cultural Setting (U.S. preschool, "westernized" Chinese preschool, and traditional Chinese preschool), and the interaction term. We ran our models using a Type II model comparison procedure, i.e., our initial model included all main effects and the two-way interaction and then we excluded the interaction effect if it did not contribute to the model significantly.

Verbal teaching

Given that the model with the interaction between Age Group and Cultural Setting did not add significant variance in children's verbal teaching above the main effects [$\chi^2_{(2,140)} = -0.62, p = 0.735$], we ran the model with main effects only. This model was significant, $\chi^2_{(3,142)} = 33.98, p < 0.001$. Age Group explained a significant amount of variability in children's verbal teaching, $B = 1.31, SE = 0.25, z = 5.20, p < 0.001, OR = 3.69, CI [2.27, 6.08]$, revealing that older children engaged in more verbal teaching than younger children. Cultural Setting was also significant, suggesting that children from traditional Chinese preschool engaged in less verbal teaching than their counterparts in the U.S. preschool, $B = -0.66, SE = 0.30, z = -2.17, p = 0.030, OR = 0.52, CI [0.28, 0.92]$. Children from traditional Chinese preschool did not differ in their use of verbal teaching from "westernized" Chinese preschool ($B = -0.61, SE = 0.31, z = -1.96, p = 0.050, OR = 0.54, CI [0.29, 1.00]$), nor did those from "westernized" Chinese preschool differ from their counterparts in the U.S. preschool ($B = -0.04, SE = 0.30, z = -0.14, p = 0.892, OR = 0.96, CI [0.53, 1.74]$).

Contrastive teaching

The model with the interaction term for contrastive teaching did not add significant variance in children's contrastive teaching above the main effects [$\chi^2_{(2,140)} = 4.42, p = 0.110$], hence we ran the model with main effects only. This model was significant, $\chi^2_{(3,142)} = 17.62, p < 0.001$. Age Group explained a significant amount of variability in children's verbal teaching, $B = 1.18, SE = 0.33, z = 3.59, p < 0.001, OR = 3.26, CI [1.74, 6.37]$, revealing that

TABLE 1 Average teacher ratings on pedagogical beliefs and practices across cultural settings.

		Questions included	U.S. preschool <i>M</i> (<i>SD</i>)	Traditional Chinese preschool <i>M</i> (<i>SD</i>)	“Westernized” Chinese preschool <i>M</i> (<i>SD</i>)
Pedagogical beliefs	Learner-centered approaches	Activities to be responsive to individual children’s interests.	5.00 (0)	4.60 (0.57)	4.60 (0.57)
	Teacher-directed approaches	Teacher to talk to the whole group and for the children to do the same thing at the same time.	1.75 (0.84)	3.96 (0.57)	2.10 (0.6)
Follow a prescribed curriculum plan without being distracted by children’s interests or current circumstances.					
Pedagogical practices	Learner-centered approaches	Engage in child-chosen, teacher-supported play.	4.50 (0.57)	3.30 (0.57)	4.00 (0.57)
	Teacher-directed approaches	Participate in whole-class, teacher-directed instruction.	2.00 (0.57)	4.60 (0.57)	4.00 (0.57)

Pedagogical beliefs were rated on a 5-point scale from “Not at all Important” (0) to “Extremely Important” (5). Pedagogical practices were rated on a 5-point scale from “Almost Never” (0) to “Very Often” (5).

TABLE 2 Proportion of children using different teaching styles and content.

		Teaching styles			Teaching content
		Non-verbal teaching	Verbal teaching	Contrastive teaching	Contingent teaching
U.S. preschool	Younger	1.00	0.37	0.09	0.20
	Older	0.92	0.66	0.34	0.52
Traditional Chinese preschool	Younger	0.98	0.24	0.12	0.16
	Older	0.96	0.50	0.13	0.29
“Westernized” Chinese preschool	Younger	0.96	0.32	0.10	0.22
	Older	0.95	0.70	0.35	0.53

older children engaged in more contrastive teaching than younger children. There were no significant cultural differences found.

Teaching content

Table 2 also displays the proportion of trials in which children engaged in *contingent teaching*. Inspection of Table 2 indicates an age-related increase in the likelihood of children engaging in contingent teaching. Additionally, U.S. and “westernized” Chinese preschool appeared to be more likely to engage in contingent teaching compared to traditional Chinese preschool children. Similar to the analysis for teaching style, due to the poor fitting of a mixed-effects binomial logistic regression model, we opted to analyze the likelihood that children engaged in contingent teaching through the repeated binomial trial model. The models included Age Group (Younger, Older), Cultural Setting (U.S. preschool, “westernized” Chinese preschool, and traditional Chinese preschool), and their interaction term. Like our analysis plan above, we ran our models using a Type II model comparison procedure.

The model with the interaction term for contingent teaching did not add significant variance in children’s contrastive teaching above the main effects [$\chi^2_{(2,140)} = 1.14, p = 0.565$], hence we ran the model with main effects only. The main effects model

was significant, $\chi^2_{(3,142)} = 27.39, p < 0.001$. Specifically, Age Group significantly predicted children’s contingent teaching, $B = 1.23, SE = 0.27, z = 4.55, p < 0.001, OR = 3.42, CI [2.03, 5.87]$, revealing that older children engaged in more contingent teaching than younger children. Cultural Setting also significantly predicted contingent teaching in children, where children from traditional Chinese preschool engaged in less contingent teaching than their counterparts in the U.S. preschool, $B = -0.71, SE = 0.33, z = -2.15, p = 0.032, OR = 0.49, CI [0.26, 0.93]$. Children from traditional Chinese preschool also engaged in less contingent teaching than those from “westernized” Chinese preschool, $B = -0.75, SE = 0.34, z = -2.21, p = 0.027, OR = 0.47, CI [0.24, 0.91]$. There were no cultural differences found in contingent teaching between children from “westernized” Chinese preschool and those in the U.S. preschool ($B = 0.05, SE = 0.31, z = 0.15, p = 0.883, OR = 1.04, CI [0.56, 1.94]$).

Cultural variability in children’s mental state reasoning abilities

Knowledge attribution

A 2 (Age Group: Younger, Older) \times 3 (Cultural Setting: U.S. preschool, “westernized” Chinese preschool, and traditional

Chinese preschool) ANOVA was conducted on children's total knowledge attribution score. The model with the interaction term did not add significant variance in knowledge attribution above the main effects [$\chi^2_{(2,140)} = 0.37, p = 0.657$], so we ran the model with main effects only. The model with main effects was significant, $\chi^2_{(3,142)} = 8.57, p < 0.001$. Results showed that only Age Group significantly predicted knowledge attribution scores, $F = 18.77, p < 0.001, \eta_p^2 = 0.12$. The main effect of Culture was not significant, $F = 0.45, p = 0.641$. Across the three cultural settings, older children ($M = 2.19, SD = 0.49$) were better at differentiating the three learners' understanding of the game based on their mistakes compared to younger children ($M = 1.74, SD = 0.88$).

False belief understanding

A binary logistic regression model was conducted to examine the effect of Age Group (Younger, Older) and Cultural Setting (U.S. preschool, "westernized" Chinese preschool, and traditional Chinese preschool) on children's binary false belief score. The model with the interaction term did not add significant variance in knowledge attribution above the main effects [$\chi^2_{(2,140)} = 1.20, p = 0.55$], so we ran the model with main effects only. The main effects model significantly explained more variance than the null model, $\chi^2_{(3,142)} = 28.01, p < 0.001$. Only Age Group significantly predicted whether children passed the false belief task, $B = 1.91, SE = 0.39, z = 4.94, p < 0.001, OR = 6.75, CI [3.24, 14.86]$.

Overall, these results suggest that the mental state reasoning abilities underlying teaching develop similarly across U.S. and China. In all three cultural settings, older children demonstrated more sophisticated knowledge attribution ability and a better understanding of false beliefs.

Mental state reasoning abilities in children's teaching strategies

Due to the poor fitting of mixed-effects binomial logistic regression models, we opted to analyze the effects of knowledge attribution and false belief understanding on children's teaching across the three cultural settings with the repeated binomial trial models. Knowledge attribution and false belief understanding scores were added to the model with Age Group (Younger, Older) and Cultural Setting (U.S. preschool, "westernized" Chinese preschool, and traditional Chinese preschool) to examine if these mental state reasoning abilities explained significant variance in children's teaching over and above age and cultural differences. We only analyzed children's verbal teaching, contrastive teaching, and contingent teaching as there was no variability in their non-verbal teaching.

Verbal teaching

The model that included knowledge attribution and false belief scores added significant amount of variance in children's verbal teaching over and above age and cultural differences, $\chi^2_{(2,140)} = 10.18, p = 0.006$. After controlling for Age Group and Cultural Setting, knowledge attribution significantly predicted children's

verbal teaching, $B = 0.65, SE = 0.24, z = 2.76, p = 0.006, OR = 1.92, CI [1.24, 3.15]$, suggesting that children with higher knowledge attribution scores engaged in more verbal teaching than those with lower knowledge attribution scores. The main effect of false belief was not significant, $B = 0.20, SE = 0.29, z = 0.72, p = 0.474, OR = 1.23, CI [0.70, 2.14]$.

Contrastive teaching

The model that included knowledge attribution and false belief scores added significant amount of variance in children's contrastive teaching over and above age and cultural differences, $\chi^2_{(2,140)} = 22.16, p < 0.001$. There was a significant effect of false belief understanding, $B = 1.35, SE = 0.46, z = 2.93, p = 0.003, OR = 3.84, CI [1.64, 10.18]$, indicating that children who passed the false belief task engaged in more contrastive teaching than those who did not. Additionally, knowledge attribution significantly predicted children's contrastive teaching, $B = 1.08, SE = 0.34, z = 3.15, p = 0.002, OR = 2.96, CI [1.54, 5.94]$, suggesting that children with higher knowledge attribution scores engaged in more contrastive teaching than those with lower scores.

Contingent teaching

The model that included knowledge attribution and false belief scores added significant amount of variance in children's contingent teaching over and above age and cultural differences, $\chi^2_{(2,140)} = 9.50, p = 0.009$. Controlling for Age Group and Cultural Setting, knowledge attribution significantly predicted children's contingent teaching, $B = 0.67, SE = 0.27, z = 2.54, p = 0.011, OR = 1.96, CI [0.20, 3.40]$, indicating that children with higher knowledge attribution scores engaged in more contingent teaching than those with lower scores. The main effect of false belief was not significant, $B = 0.32, SE = 0.31, z = 1.01, p = 0.315, OR = 1.37, CI [0.74, 2.55]$.

Teachers' pedagogical beliefs and practices

Table 1 presents the mean scores of preschool teachers' ratings of their pedagogical beliefs and practices across cultural settings. An examination of Table 1 reveals that teachers in the U.S. and "westernized" Chinese preschools endorsed learner-centered but not teacher-directed pedagogical beliefs. Preschool teachers in all three cultural settings considered being responsive to children's interests and needs as "extremely important" (U.S. preschool teachers: $M = 5, SD = 0$; traditional Chinese preschool teachers: $M = 4.6, SD = 0.57$; "westernized" Chinese preschool teachers: $M = 4.6, SD = 0.57$). Traditional Chinese preschool teachers also endorsed teacher-directed pedagogical beliefs, rating them as "very important" ($M = 3.96, SD = 0.57$), whereas U.S. and "westernized" Chinese preschool teachers rated them as "not at all important" (U.S. preschool teachers: $M = 1.75, SD = 0.84$; "westernized" Chinese preschool teachers: $M = 2.10, SD = 0.6$).

Teachers in the U.S. and "westernized" Chinese preschools also highlighted the importance of learner-centered, but not teacher-directed practices. They reported engaging in child-chosen, teacher-supported play activities "regularly (2–4 times a week)" to "daily" (U.S. preschool teachers: $M = 4.5, SD = 0.57$; "westernized"

Chinese preschool teachers: $M = 4$, $SD = 0.57$), while traditional Chinese preschool teachers reported doing so “sometimes” ($M = 3.3$, $SD = 0.57$). When asked about the frequency of whole-class, teacher-directed instruction, U.S. preschool teachers reported it occurred “rarely” (U.S.: $M = 2$, $SD = 0.57$). In contrast, both traditional and “westernized” Chinese preschool teachers reported higher frequencies of teacher-directed instruction, with it occurring “daily” in traditional Chinese classrooms ($M = 4.6$, $SD = 0.57$), and “regularly (2–4 times a week)” in “westernized” Chinese classrooms ($M = 4$, $SD = 0.57$).

Overall, these responses highlight cultural differences in pedagogical beliefs and practices. U.S. preschool teachers endorsed and practiced a learner-centered pedagogy. Traditional Chinese preschool teachers endorsed both learner-centered and teacher-directed pedagogies but primarily practiced the teacher-directed approach. Meanwhile, teachers in the “westernized” Chinese preschool endorsed pedagogical beliefs and practices more similar to those in the U.S. classrooms than to those in traditional Chinese classrooms.

Discussion

We explored cultural differences in the development of 3- to 7-year-old children’s teaching, the mental state reasoning abilities linked to their teaching, and the relationship between the two. Participants from three cultural settings (i.e., U.S. preschool, traditional Chinese preschool, and “westernized” Chinese preschool) taught learners how to play a game in which the goal was to match a colored piece to a colored square. We evaluated children’s teaching styles by observing their use of verbal teaching and contrastive teaching (i.e., comparing what the learner should and should not have done) and whether the content of children’s teaching was specific to the learners’ mistakes (i.e., contingent teaching). Additionally, we measured children’s mental state reasoning, including knowledge attribution to the learners and false belief understanding. We identified cultural differences in children’s teaching style and content and found associations between mental state reasoning and children’s teaching strategies. Finally, we provide evidence that the pedagogical beliefs and practices espoused by children’s teachers which differed across cultural settings are mirrored in children’s own teaching. Below, we delve deeper into these findings before discussing the broader implications of these data.

Our results are consistent with prior work reporting age-related changes in children’s teaching and mental state reasoning. Firstly, our results across the three cultural settings indicated that younger children primarily teach through demonstration while older children were more likely to engage in verbal teaching, employ contrastive teaching, and tailor the content of their teaching to the learners’ mistakes. This aligns with previous research showing that children develop more sophisticated teaching abilities with age (e.g., Davis-Unger and Carlson, 2008; Ronfard and Corriveau, 2016; Strauss and Ziv, 2012; Strauss et al., 2002; Ziv et al., 2016). Furthermore, across the three cultural settings, older children demonstrated a greater ability to make accurate inferences regarding the learners’ knowledge based on their mistakes compared to younger children. They were also more

likely to pass the false belief task. Our results are consistent with prior research demonstrating that young children’s mental state reasoning develops with age (e.g., Wellman and Liu, 2004; Ronfard and Corriveau, 2016).

In line with our hypothesis, cultural differences were observed in verbal teaching and contingent teaching. Specifically, our results indicated that children from the traditional Chinese preschool were less likely to engage in verbal teaching than their counterparts from the U.S. preschool. They were also less likely to engage in contingent teaching compared to children from U.S. and “westernized” Chinese preschools. Evidence of cultural scripts shaping children’s teaching strategies is reflected in preschool teachers’ ratings of pedagogical beliefs and practices across the three cultural settings. Teachers from U.S. and “westernized” Chinese preschools endorsed learner-centered approaches to teaching more often than those teachers from the traditional Chinese preschool. Consequently, children from U.S. and “westernized” Chinese preschools, who were more frequently exposed to learner-centered teaching approaches, taught in a manner reflective of their learning environment. Conversely, children from the traditional Chinese preschool, familiar with teacher-directed approaches, exhibited teaching strategies that aligned with those beliefs and practices. Taken together, the results indicate that children’s teaching strategies correspond with their preschool teachers’ reported pedagogical beliefs and practices across the three cultural settings. This is consistent with previous research indicating that exposure to a primarily verbal mode of teaching leads to the internalization of that teaching style (LeVine et al., 2011; Visscher, 2010). Our results suggest that a similar internalization process occurs earlier in development concerning the strategies children use to address a learner’s mistakes.

To our surprise, we did not find cultural differences in children’s contrastive teaching. One explanation for this finding is that our categorization of contrastive teaching in the present study may not accurately reflect “learner-centered” teaching practices. For example, while a child who contrasted and emphasized both pieces of information to the learner who made a single error is coded as employing contrastive teaching, the content being taught does not specifically address the learner’s particular mistake. Additionally, the ability to contrast what a learner should and should not do may be more influenced by cognitive factors than cultural ones. This is because contrastive teaching requires children to closely observe and remember the learner’s actions, accurately recall the correct way to perform the task, and then articulate the differences between the learner’s actual performance and the ideal performance (e.g., Strauss and Ziv, 2012). This process involves advanced cognitive skills like the ability to reason about the learner’s knowledge, rather than merely reflecting the cultural teaching methods they have been exposed to. Building on Ronfard and Corriveau (2016), our results showed that children with enhanced knowledge attribution abilities and a more sophisticated understanding of false belief were more likely to engage in contrastive teaching than those with poorer knowledge attribution skills and false belief understanding.

Our results also documented links between mental state reasoning and the other teaching strategies measured. Expanding on previous work (e.g., Strauss et al., 2002; Davis-Unger and Carlson, 2008; Ye et al., 2021; Ziv et al., 2016), we found that knowledge attribution abilities was positively associated not

only with teaching verbally, but also teaching specifically to a learner's mistakes. False belief understanding was predictive of neither verbal teaching nor contingent teaching. This indicates that the ability to infer a learner's knowledge from mistakes may be more crucial than general false belief understanding in explaining sophisticated teaching strategies in young children. Another explanation is that passing the unexpected-contents false belief task used in our study, which primarily involves recognizing knowledge differences between oneself and another person, may not be sufficient for effective teaching (Ye et al., 2021). In contrast, the location false belief task, which requires tracing the mental states of others, might be a more suitable measure of false belief understanding in a teaching context as it captures an essential precursor to teaching—the ability to track different learners' knowledge. It is also important to note that children across the three cultural settings did not differ in their knowledge attribution ability nor in their false belief understanding. This indicates that the cultural differences we observed in children's teaching are rooted in the pedagogical beliefs and the teaching practices they experienced most often rather than mental state reasoning abilities. Alongside the significant cultural differences found in children's verbal and contingent teaching, this suggests that while knowledge attribution may universally support children's teaching by enabling them to represent the mental states of others, the specific teaching strategies they employ are strongly shaped by their culture's pedagogical script. Therefore, both cognitive development and cultural experiences play pivotal roles in shaping children's teaching strategies. The capacity to infer knowledge from mistakes may be essential for verbal and contingent teaching. Nonetheless, whether children adopt these teaching strategies is influenced by their own experiences as learners, specifically their exposure to the preferred teaching strategies within their culture.

The current study is one of the first to explore both inter and intra-cultural differences on the development of children's teaching strategies. This is crucial for understanding how cultural contexts such as educational practices and beliefs shape children's behavior. These results expand on Kim et al. (2018) study in showing cultural variation not only in children's choice on whom to teach, but also their teaching style and content. The observed cultural variability within China highlights the diversity of pedagogical beliefs and practices within a single culture and their significant influence on children's teaching strategies. We found significant differences between children attending learner-centered and teacher-directed schools in their likelihood to use verbal and contingent teaching strategies. Within China, variations in the use of contingent teaching can be observed between children attending traditional preschools and those in "westernized" preschools. This illustrates how children's teaching strategies are influenced by the evolving educational practices shaped by globalization and cultural shifts. These findings are particularly relevant given the diverse pedagogical beliefs and practices endorsed by preschool teachers in different cultural settings globally. Studying these variations not only enhances our understanding of cultural influences on how children transmit information to others, but also informs educational practices that support diverse learning environments globally.

It is important to note that the cultural differences observed in the present study may be a proxy for other important factors that influence children's teaching strategies. Our study focused on variability across formal educational settings, but children's teaching is likely to be shaped by the sum total of their teaching experiences which include formal and informal settings. Moreover, although we observed differences, the magnitude of these differences may be relatively small when compared to children growing up in places without formal schooling. Unlike societies with formal education systems (e.g., U.S. and China), direct communication with an adult caregiver is rare in small-scale societies where less costly forms of teaching, such as observation, are prioritized (Scribner and Cole, 1973; Rogoff, 2003; Paradise and Rogoff, 2009). Recent work has also shown that children's understanding of teaching varies between societies with formal and informal education systems. For instance, ni-Vanuatu children emphasized what they taught rather than how they taught or the learner's level of comprehension (Brandl et al., 2023a). Additionally, teachers in schools serving economically disadvantaged communities may hold different pedagogical beliefs and practices compared to those in more advantaged settings, often influenced by perceptions of student capabilities (Rubie-Davies et al., 2012; Solomon et al., 1996). These differences in teacher beliefs and practices, shaped by socioeconomic contexts, could in turn influence children's own teaching strategies.

Further investigation is warranted into three potential limitations of the current study, which are linked to the specific materials and procedures employed. Firstly, we did not gather information from parents regarding their pedagogical beliefs and practices nor did we obtain data about children's beliefs or socio-motivational justifications for their teaching strategies. As a result, the impact of parents on children's teaching strategies remains unclear. For instance, Chinese parents influenced by Western cultures may prioritize fostering children's individuality (Zhu and Zhang, 2008; Xu et al., 2014), adopting a more learner-centered approach to teaching. Preschools in China vary on a continuum of teacher-directed approach to child-centered, play-based approach (Tobin et al., 2009; Zhu and Zhang, 2008). Similarly, our U.S. sample was drawn from settings that emphasize a learner-centered curriculum, but diverse pedagogical approaches within the U.S. may result in U.S. children developing teaching styles that are less learner-centered. Future studies should include measurements on parental and children's pedagogical beliefs as well as justification questions to explore more nuanced relations between cultural input and children's teaching.

Recall that in the current study, the teachers reported on their own pedagogical beliefs and practices. As the aim of the present study was to investigate the pedagogical beliefs and practices of familiar teachers, one limitation is that the self-report questionnaire was administered to a limited number of teachers, constraining our ability to perform statistical analyses. Future work should include a larger sample of teachers, as well as classroom observation across different settings to explore more systematically whether general teacher pedagogical beliefs and practices are linked to variations in children's own teaching strategies. Moreover, our sample did not include a direct

comparison group of U.S. children attending a teacher-directed preschool. This is because preschools in the U.S. tend to follow a largely learner-centered approach (Barnett and Jung, 2024) unlike the variations observed between learner-centered and teacher-directed approaches in Chinese preschools. Future work should explore potential relations between US teachers' pedagogical beliefs and practices and children's teaching strategies. Such work would help to tease apart potential differences based on culture vs. pedagogical approaches.

Lastly, contingent teaching was coded in the present research as a binary variable, indicating whether or not children tailored their teaching to the specific mistakes made by learners. This binary approach may not have sufficiently captured the nuances of children's teaching content when contingent teaching was absent. In such cases, children may have either been under-informative by providing insufficient information, or over-informative by offering more information than necessary. Some work has looked at children's evaluations of a teacher's under- and over-teaching behavior (e.g., Bass et al., 2022; Gweon et al., 2014, 2018), but future research would benefit from an examination of the conditions under which children themselves choose to engage in under- and over-teaching.

In summary, the current study explored inter and intra-cultural differences on children's teaching strategies. Our findings underscore the distinct influences of cultural input and cognitive development on children's teaching strategies. Taken together, our results show that, although teaching may be a natural cognitive ability, the specific strategies they employ are shaped by cultural input.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Boston University Institutional Review Board Charles River Campus (IRB-CRC). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed

consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

NY: Formal analysis, Writing – review & editing. YC: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SR: Supervision, Writing – review & editing, Conceptualization, Methodology. KC: Supervision, Writing – review & editing, Conceptualization, Methodology.

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