The role of child gender and age in teacher-child relationship, self-regulation, social emotions and academic achievement in preschool: A multi-group structural equation modeling approach

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Abstract

This study explored the relationships among teacher-child relationship (TCR), self-regulation (SR), social emotions (SE), and children's learning of mathematics and vocabulary while considering the influence of gender and age. Two hundred seventy children (boys = 154, girls = 116) aged 3-6 years (Mage = 59.44 months) participated across 18 classes in three preschools. The results from multi-group structural equation modeling (SEM) revealed significant gender differences of TCR when predicting SR and SE. However, no significant gender differences were observed when SR predicted mathematics and vocabulary, or SE predicted these two. SR emerged as the most potent predictor of mathematics for all children. Furthermore, significant age variations were identified in TCR when predicting SR and SE and when SR and SE predicted mathematics and vocabulary. Finally, the research discusses implications for teachers, emphasizing the importance of tailored support for children of different genders and age groups to enhance TCR, SR, and SE.

Introduction

Over the past two decades, researchers have diligently sought to identify the crucial factors for ensuring children's long-term success in school. Among these factors, teacher-child relationship (TCR) stands out as a proximal predictor of early education outcomes, ultimately influencing children's developmental trajectories (Sankalaite et al., 2021). Gender differences in TCR have also garnered attention within this research landscape (Acar et al., 2022). Notably, girls tend to exhibit more closeness in TCR than boys (Cadima et al., 2019). This heightened closeness TCR, in turn, corresponds to greater self-regulation (SR) and positive social emotions (SE) among girls, while boys are more likely to experience conflict in TCR (Yang et al., 2022), potentially impeding the development of SR and SE. Furthermore, teachers adopt different focuses when interacting with children of varying ages (Koepke & Harkins, 2008). Younger children typically receive more social-emotional support (Horn et al., 2021), whereas teachers' interactions with older children may center more on academic achievement (Jones & Bouffard, 2012).

SR and SE represent pivotal priorities in preschool due to their profound influence on children's academic success and social adaptation (Esenturk & Asi, 2022). Girls have demonstrated significant advantages in SR (Reilly et al., 2019) and SE development (Karaca & Bektas, 2022), with these advantages becoming more pronounced as they grow older (Berti & Cigala, 2022).

However, the intricate relationships between TCR and SR and SE, and the associations between SR, SE, and academic achievement have received limited attention across different genders (Cameron et al., 2019) and ages (Lin & Powell, 2023). Questions such as whether TCR consistently predicts SR and SE across ages, whether boys' SR and SE disadvantages hinder their academic achievement (Arnold et al., 2012), whether SR

and SE predict academic achievement consistently in younger versus older children, and whether there exists a universally predictive variable across genders and ages remain largely unexplored (Hong et al., 2009). To address the gaps, the current study explored whether gender and age differences would moderate the relationships between TCR, SE, SR, and academic achievement. By doing so, it seeks to provide implications for targeted interventions for children of different genders and ages, optimizing the beneficial impacts of TCR, SR, and SE on academic achievement.

The connection between TCR and SR, SE

TCR is recognized as cumulative, ongoing interpersonal bonds between individual children and their teachers, mainly including closeness, and conflict relationships (Hamre & Pianta, 2001). These relationships have emerged as crucial predictors of children's SR (Sankalaite et al., 2021) and SE (Mejia & Hoglund, 2016).

Primarily, close TCR fosters a warm and trusting environment, providing the emotional support necessary for active engagement in activities (Acar et al., 2022) and creating ample opportunities to develop SR (Denham et al., 2012). Furthermore, teachers, acting as agents of socialization, profoundly influence children's SE (Wang et al., 2016). Children with positive TCR exhibit a more favorable view of the school, approaching their peers with pro-social behaviors (Vitiello et al., 2022). Teachers, capitalizing on these positive relationships, can support children to socialize with their peers and foster healthy orientations toward interactions (Sankalaite et al., 2021). Moreover, closeness TCR is a buffer against the potential risks associated with poor SR (Silver et al., 2005).

Nevertheless, the benefits of TCR for SR and SE are not realized when these relationships are characterized by conflict (Sankalaite et al., 2021). Conflict TCR, marked by a lack of trust and discordant teacher-child communication, can lead to negative outcomes, including a deficit in SR (Mejia & Hoglund, 2016). Teachers, preoccupied with regulating children's behavior, inadvertently limit opportunities for SR (Paro et al., 2004). Moreover, these relationships can exacerbate children's aggressive behaviors (Paes et al., 2023), undermining overall achievement through the displacement of SR and SE development opportunities (Sandilos et al., 2019).

The relationship between SR and development in mathematics and vocabulary

SR, which encompasses cognitive, emotional, and behavioral functioning (Denham et al., 2012) has concurrent and longitudinal predictive effects on children's academic performance, particularly in mathematics (Peng & Kievit, 2020). One key aspect is the shared physiological basis between SR and mathematics. Children's mathematical development relies on a neurobiological foundation for SR (Rosenberg-Lee et al., 2011). Children with stronger SR demonstrate greater mathematical competence compared to those with weaker SR (Simanowski & Krajewski, 2019). Remarkably, even after accounting for covariates such as gender and age (Blair & Raver, 2015), increases in SR significantly enhance mathematics (Simanowski & Krajewski, 2019). Notably, this effect holds consistently across different cultures (Lan et al., 2011). Furthermore, SR exhibits a strong connection with children's vocabulary (Butterfuss & Kendeou, 2018). Children with stronger SR tend to excel in vocabulary and growth compared to those with weaker SR (Korucu et al., 2022). This link may be attributed to SR prompting children to focus their attention, process information from multiple sources, and provide more opportunities for vocabulary acquisition (Rojas & Abenavoli, 2021).

The relationship between SE and development in mathematics and vocabulary

Children's SE, which encompasses self-awareness, social awareness, self-management, relationship skills, and responsible decision-making (*CASEL* , 2017), is a dynamic process where children engage with their environments, resulting in effective interactions that promote learning (Curby et al., 2015). Children with stronger SE tend to have more opportunities for active classroom participation and are more likely to receive constructive feedback from teachers (Denham & Brown, 2010). These interactions, in turn, foster children's academic development, encompassing areas such as mathematics and language skills (Dobbs et al., 2006).

Research has consistently shown that SE significantly predicts mathematics, even when accounting for children's language (Denham et al., 2012). Conversely, children facing challenges in SE tend to exhibit lower

early mathematics (Marsh et al., 2002). Moreover, SE exhibits stability in predicting mathematics in both high- and low-risk children (Doctoroff et al., 2016). Furthermore, SE is strongly correlated with vocabulary. Even after adjusting for factors like age and attention, children demonstrating higher SE in preschool tend to achieve higher-quality language scores in primary school (Jerome et al., 2009). SE emerges as a protective factor and a significant predictor of long-term growth in children's vocabulary (Mackintosh & Rowe, 2021).

Gender Differences

Given the close connection between TCR, SR, and SE, recent studies have shed light on consistent gender patterns among preschoolers in these behaviors (Walker & Graham, 2021). Grounded in gender role socialization, researchers posit that girls tend to foster more close relationships with teachers, while boys lean towards peer interactions (Walker & Graham, 2021). Consequently, TCR is closer with girls compared to boys, resulting in fewer conflicts (Zahn-Waxler et al., 2008). However, the gender role as a central focus in the connection between TCR, SR, and SE has yielded contradictory results. Some research indicates that girls tend to develop stronger behavioral regulation and emotional understanding when they have positive TCR (Ewing & Taylor, 2009). Conversely, boys in conflict TCR may exhibit more aggressive behavior (Brock & Curby, 2014), and these effects can be long-lasting (Jerome et al., 2009). However, other studies suggest that although gender differences exist in TCR, their impact on SR and SE (Horn et al., 2021) does not exhibit significant gender differences.

Meanwhile, these inconsistent findings extend to the moderating role of gender in SR, SE, and academic performance. Some studies point to girls outperforming boys in SR (Reilly et al., 2019), SE (Karaca & Bektas, 2022), and vocabulary (Bornstein et al., 2004). Conversely, boys tend to excel in mathematics (Lin & Powell, 2023). Potential factors contributing to the achievement gap between girls and boys include differences in children's SR (George & Robitzsch, 2018) and SE (Veijalainen et al., 2019). For example, girls' prosocial behavior tends to have a stronger relationship with academic knowledge than boys' behavior (Bierman et al., 2009). Although multiple studies indicate that SR, SE, and academic performance are interconnected developmental processes (Salmon et al., 2016), there are inconsistent findings as well (Slot et al., 2020). Gender differences in SR may vary across different cultures, being more pronounced in the Western settings (Matthews et al., 2009) and less significant in Asian contexts (Wanless et al., 2011). No evidence suggesting that gender influences the relationship between SR and academic achievement (Montroy et al., 2014). Additionally, gender differences in academic performance are not pronounced in the 3-6 age range (Entwisle et al., 2007), and girls' vocabulary advantage may diminish after age 6 (Bornstein et al., 2004). Moreover, in tasks related to numeracy (Hutchison et al., 2019) or SE (Doctoroff et al., 2016), there appear to be no significant gender differences.

In light of these conflicting findings concerning the moderating influence of gender on TCR, SR, SE, and academic achievement, further research is essential. Exploring whether gender differences universally act as moderating factors, which variables are moderated by these gender differences, and how different genders exhibit variations in these variables will provide valuable insights into the complex relationships among them.

Age Differences

Age may influence the connections between TCR and children's characteristics, and between children's different behaviors (Nurmi, 2012). For example, there may be age variations in the patterns of closeness TCR, whereas patterns of conflict TCR may remain consistent across ages (Horn et al., 2021). This could be attributed to teachers placing more emphasis on social emotions when interacting with younger children (Jones & Bouffard, 2012). Younger children have more opportunities to engage with teachers and discuss their feelings, fostering a closer TCR. In contrast, older children might have fewer interactions with teachers and rely more on peer support, potentially affecting the closeness TCR. However, the absence of significant age differences in conflict TCR might be due to younger children having greater difficulties regulating their emotions, leading to a stronger positive correlation between adjustment problems and conflict TCR (Koepke & Harkins, 2008). In contrast, older children's desire for autonomy might contribute to conflicts with teachers (Rudasill, 2011). Nevertheless, Mejia and Hoglund's (2016) cross-lagged study did not find age differences

in TCR, and the contribution of adjustment problems to TCR remained stable across children of different ages.

Children's SR develops rapidly with age (Berti & Cigala, 2022), with older children outscoring younger ones on SR measures. Younger children also tend to benefit more from SR interventions compared to older ones (Diamond & Lee, 2011). It has also been observed that age differences moderate the link between SR and mathematics in children (Zhong et al., 2022), as SR tends to improve with age, with inhibitory control and working memory playing crucial roles in mathematics learning (Wang & Sperling, 2020). Differences in young children's SR can directly impact mathematics.

Children's SE becomes more pronounced with age (McTaggart et al., 2022). The association between SE and academic achievement is moderated by age, with older children achieving higher academic scores, possibly due to increased exposure to social contexts facilitating learning (Curby et al., 2015). The link between social behavior and language development is also more robust in older children (Slot et al., 2020). Younger children's mathematics appears to develop separately from their SE (Cameron et al., 2019). There is a bidirectional relationship between children's SE and language (Slot et al., 2020), but whether this association is moderated by age is still unclear.

Children's mathematics develops with age (Slot et al., 2020) and associations between children's mathematics and other variables remain stable with age (Lin & Powell, 2023). However, the moderating effect of age is no longer present in primary school (Hong et al., 2009). Young children's vocabulary and reading comprehension levels increase significantly with age, with the most notable difference observed in vocabulary (Below et al., 2010).

In sum, the literature highlights the impact of age on these variables while also providing preliminary, albeit inconsistent, evidence of age moderating the relationships between them. However, there is limited systematic evidence regarding whether and how age moderates the relationship between TCR and behavioral development and whether this relationship varies across ages. Therefore, this study aims to explore these interrelationships from the perspective of a moderating variable, hypothesizing that grade plays a moderating role.

The present study

The current study employs a multi-group SEM to assess potential variations in the effects of genders and ages on the modeling of these above relationships. Additionally, it aims to identify which factors would exert the most significant predictive influence. To fill up the research gaps, we formulated a hypothesized model to evaluate heterogeneity across genders and ages (see Figure 1) with the following key questions:

1. What are the gender and age differences in TCR, SR, SE, and children's development in mathematics and vocabulary?
2. How does the hypothesized model apply to children of different genders?
3. How does the hypothesized model apply to children of different ages?

<Insert Figure 1 HERE>

Method

Participants

The present study was conducted in Shenzhen, one of the leading cities in China where early childhood education (ECE) has been well developed. A convenience sample of three public preschools was selected from the same community, serving families of the same socioeconomic status. In the preschools, a stratified sample of two classes each of K1, K2 and K3, totaling 18 classes, and then a random sample of 15 children from each class participated in the study, comprising 90 children from K1 (M = 47.72, SD = 0.36), 90 from K2 (M = 59.72, SD = 0.39), and 90 from K3 (M = 70.87, SD = 0.44). In China, children typically begin preschool at around the age of 3 and transition to primary school between 6 and 7 (Xie & Li, 2019). The different grades represent different age groups, with children in K1 aged 3-4 years, K2 aged 4-5 years, and K3

aged 5-6 years. To facilitate multi-group comparisons across ages, we transformed the continuous numerical variable of age into the categorical variable of grade level. The sample included 154 (57%) boys and 116 (43%) girls. All lead teachers from the 18 classes were female, with an average teaching experience of 8.94 years (SD=6.09), ranging from 4 years to 27 years (see Table 1).

<Insert Table 1 HERE>

Procedures

The project received approval from the authors' university's Survey and Behavioral Research Ethics Committee (SBREC). The initial step involved the second author meeting with preschool principals to discuss participation and providing a detailed explanation of the study to obtain consent from willing teachers. Once teacher consent was secured, the lead teachers from the selected 18 classes proceeded to rate their relationships with the individual children participating in the study.

To ensure scorer consistency, six research assistants(RA) with master's degrees in ECE were recruited and divided into three groups of two individuals each, with each group responsible for assessing K1, K2, and K3 children's SR, SE, mathematics, and vocabulary. These RA attended a comprehensive 2-day face-to-face workshop, including grading practice, where the researchers partnered with the RA to conduct child assessments. Once the RA achieved the same score as the researchers, they began working in pairs to conduct formal assessments.

All assessments were conducted in a quiet preschool room, with four assessments lasting approximately 30 minutes per child. Before the assessment, the researchers established a positive relationship with the child through play to ensure their comfort. At the end, children received stickers as tokens of appreciation for their participation.

Measures

Preschool individual teacher-child relationship

In the current study, we utilized the Student-Teacher Relationship Scale (STRS, Pianta & Nimetz, 2001), a well-established tool to gauge teachers' perceptions of their relationship with individual children. The STRS encompasses two key sub-scales: closeness and conflict. Specifically, the closeness scale consists of 11 items that assess the extent of warmth and harmonious interactions within TCR. The conflict scale comprises 12 items designed to capture any negative or confrontational aspects of these relationships. All items were rated on a 5-point Likert-type scale, with responses ranging from 1 (definitely not applicable) to 5 (definitely applicable). The lead teachers from 18 classrooms were invited to report on their relationships with 15 randomly sampled children, and instructions for completing the scale were given by the researchers before the teachers filled it out. To enhance the model fit, we excluded two items from the closeness scale and four from the conflict scale. All remaining factor loadings exceeded 0.50 and the two-factor model demonstrated an adequate fit to the data: $x^2/df = 246.677/123 = 2$, CFI = 0.925, TLI = 0.906, SRMR = 0.061, RMSEA = 0.061. Furthermore, the internal consistencies of the scales were notably high, with $\alpha_{\text{Closeness}} = 0.842$ and $\alpha_{\text{Conflict}} = 0.837$.

Direct assessment of social emotions and mathematics

The study utilized the International Development and Early Learning Assessment (IDELA), developed by Save the Children (Halpin et al., 2019), to measure children's development, encompassing various domains such as social emotions, mathematics, executive function, and literacy. The scale is evidenced by extensive validation studies in China (Huang & Siraj, 2023) .

For the current study, we specifically focused on social emotions and mathematics. The social emotions assessment comprises five dimensions: personal awareness, friendships, emotional awareness, empathy, and sharing. Scores range from 0 to 25, with higher scores indicating better SE. Meanwhile, the mathematics assessment includes seven items, including comparison by size and length, sorting and classification, shape identification, number recognition, number sense, addition and subtraction, and puzzle completion. Scores

range from 0 to 47, with higher scores indicating better mathematics. Each child was measured by 2 RA, one of which took the main test in this study, and after reaching an agreement on the test scores, the other RA recorded the scores.

Both the social emotions and mathematics demonstrated strong validity in the current study. The validation for the social emotions scale was as follows: $x^2/df = 1.98$, CFI = 0.95, TLI = 0.934, SRMR = 0.054, RMSEA = 0.06, with α of 0.658. Similarly, mathematics scale's validation was as follows: $x^2/df = 1.19$, CFI = 0.905, TLI = 0.993, SRMR = 0.026, RMSEA = 0.026, also with α of 0.658.

Direct assessment of self-regulation

To assess children's SR, we employed the Head-Toes-Knees-Shoulders task (HTKS; McClelland et al., 2014), a direct assessment measure widely used for this purpose. This task comprises three parts: in the initial phase, children were instructed to touch their heads when directed to touch their toes and vice versa. In the second phase, we introduced an additional command: children were asked to touch their knees when instructed to touch their shoulders and vice versa. All four commands were presented in a shuffled sequence in the third phase. Each part consisted of 10 items, scoring ranging from 0 for an incorrect response to 2 for a correct response, with 1 point for self-corrected responses. Consequently, the total score spanned from 0 to 60. In this study, it presented good reliability with α of 0.76. The assessment process is consistent with social emotions and mathematics above.

Direct assessment of vocabulary

We employed the Peabody Picture Vocabulary Test (Campbell, 1998; Dunn & Dunn, 1965) to assess children's receptive vocabulary. This test comprises 228 colored pictures organized into four groups, resulting in 912 pictures. The testing procedure involves the examiner presenting a vocabulary word orally, and the child selects the picture that best corresponds to the word's meaning. A correct choice receives a score of 1, while an incorrect one receives 0. The PPVT has been effectively validated in China (Xu & Liu, 2021). In the current study, we calculated the total score.

Data analytic approach

In the present study, we conducted descriptive and correlation analysis in SPSS 27.0, and employed Mplus 8.0 to explore the interactions between variables. In evaluating model fit, we employed several key metrics, including the Comparative Fit Indicator (CFI), Tucker-Lewis Index (TLI), Root Mean Square of Approximation Error (RMSEA), and Standardized Root Mean Square of Residuals (SRMR). We applied the following criteria: CFI and TLI greater than or close to 0.9 (Hu & Bentler, 1999), RMSEA and SRMR less than 0.08 (Browne & Cudeck, 1992).

Results

Descriptive findings and correlations

The results of descriptive and correlation analyses are shown in Table 2, from which it can be found that there were significant correlations between them, and the SEM was deemed necessary to further explore the structural relationships between the variables.

<Insert Table 2 HERE>

Gender and grade differences among the variables

When comparing the six variables based on gender, it was found that no significant gender differences were observed except for SR. In terms of grade, significant differences were detected in five variables except for conflict TCR. As grades increased, the children tended to have higher mean scores on closeness TCR, SR, SE, mathematics and vocabulary (see Table 3). This suggests the potential for further analysis of gender and grade differences in the relationships between these variables.

<Insert Table 3 HERE>

Structural modeling of relationships among the variables

The initial analysis used SEM to construct the baseline model, M0. This model used closeness TCR and conflict TCR to predict SR, SE, mathematics, and vocabulary. The model fit indices for M0 were excellent, with $x^2/df = 0/0$, CFI = 1, TLI = 1, SRMR = 0, and RMSEA = 0. However, it was noted that the coefficients of the four paths from closeness TCR and conflict TCR to mathematics and vocabulary did not reach statistical significance. To simplify the model, these non-significant paths were removed.

Model M1 was then developed based on M0, which excluded the direct predictive paths of closeness TCR and conflict TCR to mathematics and vocabulary. The purpose of M1 was to examine whether children of different genders and grades exhibited the same model. The results indicated that this model was acceptable and suggested structural constancy among different groups in the path model. All the indicators of M1 met the fit criteria, with $x^2/df = 5.46/4$, CFI = 0.997, TLI = 0.989, SRMR = 0.037, and RMSEA = 0.015. In M1, all path coefficients reached the significance level, with the path coefficient for conflict TCR being negative, while the remaining path coefficients were positive (see Table 4).

<Insert Table 4 HERE>

Multi-group comparisons of gender for relationships among the variables

Multi-group analysis was employed to assess the model's fit across different groups. A suitable model fit would suggest that sample attribute variables had moderating effects, leading to subsequent group difference analysis. To explore potential variable variations based on demographic characteristics, nested models were constructed using the grade and gender of children as group variables, utilizing M-plus. In line with the full model, M1, equivalent models were created using multiple group comparisons within the SEM framework. Firstly, an unconstrained M2 (morphological equivalence) model was developed for gender. Subsequently, fully constrained models, M3 (loadings equivalence), were derived from M2. As presented in Table 5, the results revealed that two models (M2 and M3) exhibited acceptable fit indices. However, upon comparing the models, it was evident that there was no significant difference in χ^2 between M2 and M3. This suggested that the correlation between the variables remained consistent across genders.

<Insert Table 5 HERE>

Given the constancy of inter-variable interactions across genders, further analysis was conducted to examine the patterns of these paths across genders. Notably, boys' closeness TCR did not significantly predict SR (see Figure 2). Similarly, girls' conflict TCR did not exhibit significant effects on SE (see Figure 3). In the remaining pathways, no significant gender differences were observed. In particular, SR emerged as the strongest predictor, with predictions of mathematics and vocabulary reaching high values of 0.496 and 0.515 for boys, and 0.591 and 0.472 for girls, respectively. Additionally, closeness TCR demonstrated positive predictive effects on SE for both boys and girls, with slightly stronger predictive values for girls than for boys ($0.314 > 0.228$). The predictions of SE for mathematics and vocabulary did not exhibit gender difference. However, the predictive effect on vocabulary was somewhat greater for boys than for girls ($0.306 > 0.277$).

<Insert Figure 2 HERE>

<Insert Figure 3 HERE>

Multi-group comparisons of grade for relationships among the variables

Based on the full model, M1 created unconstrained model M4 (morphological equivalence) for grade, and then created fully constrained model M5 (loadings equivalence) from M4 (see Table 5), revealing that these two models exhibited acceptable fit indices. Unlike the gender group, a significant difference in χ^2 was observed between M4 and M5 ($_{q=23.097-13.774),with a difference in df=8 and p=0.013<0.05. This indicated that the correlation between the variables varied across grade levels, and the mo$

Further analysis of specific paths through which differences are manifested with grade as the moderating variable, distinct patterns emerged across grade levels. Specifically, among K1 children, five path coefficients

were significant, while three were not (see Figure 4). Notably, closeness TCR did not significantly predict SR and SE, and SE did not predict mathematics in this group. For K2 children, six path coefficients were significant, while two were not (see Figure 5). It was observed that closeness TCR had no significant predictive effect on SR, and SR on vocabulary was not significant. In the case of K3 children, four path coefficients were significant, while four were not (see Figure 6). Conflict TCR did not exhibit a significant predictive effect on SR and SE, while closeness TCR did not significantly predict SR, and SE on vocabulary was not significant.

Comparing the path coefficients across the three grades, it was evident that only the prediction of SR on mathematics remained significant across all grades. This effect was most pronounced for K1 ($0.364 > 0.248$, 0.255). However, significant grade differences were observed in the remaining seven paths. Specifically, conflict TCR significantly predicted SE and SR for K1 and K2. Closeness TCR had a significant predictive effect on SE for K2 and SR for K3 but was not significant for SE or SR in K1. SE exhibited a predictive effect on vocabulary for K1 and K2 and on mathematics for K2 and K3. Interestingly, SR did not significantly predict vocabulary for K2 but exhibited a strong predictive effect of up to 0.454 for K1.

<Insert Figure 4 HERE>

<Insert Figure 5 HERE>

<Insert Figure 6 HERE>

Discussion

This study aimed to investigate gender and age disparities in TCR, SR, SE, mathematics, and vocabulary among Chinese children aged 3 to 6 years. More importantly, it sought to explore how these elements interrelated across genders and ages. The results showed that gender and age led to significant differences among some of the variables and their relationships.

Gender differences in the variables

The model describing the relationships demonstrated a good fit, indicating its effectiveness in capturing the complex relationships between variables. Closeness TCR was found to positively impact children's SR and SE, while conflict TCR had the opposite effect. Both SR and SE had a positive predictive impact on mathematics and vocabulary, consistent with previous research (Valcan et al., 2020). However, gender differences were primarily manifested in terms of SR. This result could be attributed to the rapid development of SR during the preschool years (Berti & Cigala, 2022), along with noticeable differences in teachers' role expectations for children of different genders (Ewing & Taylor, 2009). Teachers expect girls to exhibit behaviors that align with societal expectations, including better SR. In contrast, expectations for boys may be lower, potentially leading to challenges for boys in SR. This gender difference underscores the significant role of social and cultural factors in gender role socialization (Hamre & Pianta, 2001). Notably, no significant gender differences were found in TCR. This may reflect the influence of different cultural and social environments on them. In China, the Ministry of Education of the People's Republic of China emphasized the importance of teachers establishing good relationships with children (MOC. 2022) which may contribute to the absence of gender differences in closeness TCR. Meanwhile, Chinese preschool teachers emphasize discipline, order, and collectivist values (Hu et al., 2015), TCR might exhibit a more authoritative approach, making conflict TCR relatively consistent across genders. Lastly, no gender differences were observed in SE and academic achievement. This further supports the idea that girls' advantages in SE and academic achievement may decrease between ages 3-6 (Bornsteinet al., 2004) or may not have fully emerged yet (Doctoroffet al., 2016). It reminds us that gender differences may manifest itself differently in various developmental stages, requiring more in-depth research to understand the reasons for these changes.

Gender differences in relationships between the variables

The multi-group SEM demonstrated a good fit for children of different genders, indicating its applicability across gender groups. We identified significant differences in the path coefficients between TCR, SR and SE

for different genders. This provides clear evidence of the critical moderating role of gender in the relationships between TCR, SR, and SE. Specifically, closeness TCR had a less pronounced predictive effect on SR in boys, while conflict TCR had a less noticeable predictive effect on SE in girls. These gender differences enrich the understanding of gender role socialization (Maccoby, 1998) which reflects distinct strategies and emotional responses adopted by boys and girls when dealing with teachers (Spiltet al., 2010). Boys may rely more on other factors to develop SR, such as peer support (Rudasill, 2011) or focusing on activities (Walker & Graham, 2021), while girls may prioritize intimacy in TCR (e.g., closeness) to fulfill their social-emotional needs (Ewing & Taylor, 2009). Researchers often assume that the influence of TCR on SR and SE applies universally to all children (Sankalaiteet al., 2021). However, this finding adds depth to the literature regarding the influence of TCR on SR and SE, and it supports the idea that gender differences exist within these relationship patterns, encouraging researchers to consider the role of gender in the impact of TCR on SR and SE when developing differentiated support strategies to support children's development.

Age differences between TCR and SR, SE

The research reveals that grade significantly influences the variables, the relationship models, and the path coefficients among children. Consistent with previous research (Berti & Cigala, 2022), it was observed that SR, SE, and academic achievement exhibited an upward trajectory as children grew older. This can be attributed to the natural developmental processes, which allowed children more opportunities for growth and increased exposure to academic environments and social contexts that promote learning (Curby et al., 2015). However, a divergence in TCR has become evident. As children grow older, their closeness to teachers increases, but conflict remains unchanged (Horn et al., 2021). This phenomenon may be attributed to the increased time teachers and children spend together, leading to a closer relationship (Loomis, 2021). Moreover, as they become more familiar with each other, they adjust their strategies for interacting harmoniously, ultimately reducing the incidence of conflict (Mejia & Hoglund, 2016).

Very importantly, the present study explored the trajectory of children's development in TCR, SR and SE from K1 to K3 in the Chinese context. Children have substantial developmental differences and needs between TCR, SR and SE in K1, K2, and K3. In China, K1 is typically the first time that children leave their homes and enter formal education (Xie & Li, 2019). Children are in the phase of social adaptation to school rules, unfamiliar with classroom norms, and teachers and children are adapting to each other (Lin et al., 2019). During this period, there is often a potential for conflicts and a lack of closeness between teachers and children (Mejia & Hoglund, 2016). This may lead to conflict in TCR during the K1, which could have a negative impact on SR and SE. Meanwhile, the establishment or strength of closeness is not yet evident, resulting in a lack of predictive effects. Children in K2 have already adapted to classroom rules and are beginning to move towards autonomy and independent problem-solving (Murray & Murray, 2004). This stage may introduce conflict TCR related to regulations and autonomy, which can negatively affect SR and SE (Koepke & Harkins, 2008; Rudasill, 2011). While the degree of closeness TCR did not significantly predict SR, it did have a predictive effect on SE. This may be because children in K2 had already acquired some self-control skills, and become familiar with the classroom environment, reaching a stage of rapid development (Zhong et al., 2022). Additionally, their increased time spent together led to a gradual increase in closeness, contributing to social emotional benefits (Loomis, 2021). Children in K3 may have matured in SR and SE (Karaca & Bektas, 2022), the impact of TCR on these aspects may no longer be significant. However, compared to K1 and K2, where the closeness TCR had no predictive effect on SR, in K3, the closeness TCR had a higher predictive effect on SR. This difference may be attributed to the demands of school readiness in K3, which place a stronger emphasis on personal responsibility and SR (Xie & Li, 2022), so there may be more children who require additional support in SR, making the closeness TCR more beneficial to these children. Additionally, in K1 and K2, young children may not have fully developed the skills that necessitate close TCR for facilitating SR. In K3 these skills may be more developed, thus enabling the closeness TCR to have a greater impact on SR.

Age differences between SR, SE, mathematics and vocabulary

Consistent with prior research (Mattera et al., 2021), children's SR consistently predicts their mathematics

across all ages. This demonstrates the robust and stable influence of SR on mathematics, possibly because these two factors share a common developmental mechanism (Rosenberg-Lee et al., 2011). Surprisingly, SR predicts vocabulary in K1 and K3 but not in K2, suggesting a divergence that might result from the long-term cumulative effects of SR development (Elliott et al., 2022). Even though the predictive effect on vocabulary is weaker in K2, children's developmental SR acquired during this stage may contribute to improved vocabulary in K3, thereby enabling them to predict vocabulary more effectively in the later grades (Korucu et al., 2022).

In contrast to the idea that children's mathematics and SE tend to develop independently (Cameron et al., 2019), our current study reveals that SE predicts mathematics in K2 and K3 but not in K1. This suggests that the relationship between SE and mathematics may vary with the developmental stage across different ages. Children in K1 are primarily focused on SE (Jones & Bouffard, 2012; Koepke & Harkins, 2008) and may not prioritize mathematics learning. They are still gradually developing their mathematics, which might explain the weaker SE-mathematics relationship at this stage. However, by K2 and K3, children are more mathematically mature, making the association between SE and mathematics more apparent. Additionally, SE, similar to SR, has long-term effects (McTaggart et al., 2022), and the maturation of SE enhances its predictive power on mathematics (Doctoroff et al., 2016).

The finding that children's SE predicts vocabulary in K1 and K2 but not in K3 contradicts established literature suggesting a stronger link between SE and literacy in older children (Slot et al., 2020). This discrepancy might have arisen because K1 and K2 children may rely more on positive social interactions to develop their vocabulary. As they grow older, their vocabulary become more mature, reducing their dependence on SE support. Alternatively, it could be attributed to teachers' emphasis on SE, particularly in K1 (Jones & Bouffard, 2012), focusing on enhancing their ability to express personal needs, which may strengthen the relationship between SE and vocabulary.

However, the differences in these results might also be attributed to variations in the priorities of different teachers, potentially influencing the relationships between SR, SE, and academic achievement. These findings underscore that the connections between SR and vocabulary, and SE and mathematics and vocabulary, may evolve at a different pace and in different developmental stages, warranting further research to gain insight into the causes and mechanisms driving these differences.

Implications and limitations

While the present study delved into the moderating effects of gender and grade in children's development, it's crucial to acknowledge certain limitations when extrapolating these findings to broader child development research. Firstly, this study is cross-sectional, and therefore, it cannot establish the causality or direction of effects (Nurmi, 2012). For example, our research explored the moderating role of gender in predicting SR impact on TCR, but it is possible that this relationship operates in the opposite direction, with gender moderating SR impact on TCR. In the future, longitudinal studies could be employed to investigate the dynamic moderating roles of gender and age in children's development. Second, the reliance on teachers' self-reports of TCR may introduce potential biases (Vitiello et al., 2022) and a substantial portion of the variance in teachers' reports of TCR can be attributed to inter-teacher differences rather than variations between individual children (Mashburn et al., 2006). This implies that different children might exhibit varying levels of TCR, even if teachers reported the same scores. Future research endeavors could consider adopting a multilevel modeling approach to accounting for the influence of teacher differences on TCR. Third, the results were obtained from a Chinese sample, and the applicability to other countries may be limited. In different cultural contexts, the gender role differentiation may be more pronounced (Spilt et al., 2012). Thus, cross-cultural replications are imperative to further elucidate potential differences between gender and grade in child development.

Despite these limitations, our findings contribute further empirical evidence from the perspective of gender and grade in the context of Chinese preschool TCR, SR, SE, and academic achievement. The varying significance in path coefficients across genders and grades suggest several areas for future research. Firstly,

our study offers further support for the role of TCR in child development, emphasizing their risk or protective effects. It also highlights the predictive influence of SR and SE on academic achievement. Furthermore, our research explores the moderating role of gender and age in the relationships between TCR, SR, and SE. Future research should expand upon this to investigate the differential impacts of gender and age on child developmental relationships. This may encompass the examination of how gender and age affect the success or failure of interventions aimed at enhancing TCR, SR and SE. Additionally, exploring variations in interactions between variables across different cultural backgrounds can ensure the generalization of results. Tracking child development longitudinally can help reveal the dynamic mechanisms by which TCR, SR, SE, and academic achievement change over time.

In addition, our results reveal that SR is a robust predictor of mathematics and vocabulary. However, we have yet to explore whether SR consistently exhibits strong predictive effects on other performance in other areas (e.g., science and literacy) across different genders and ages. It is imperative to delve into the mechanisms underlying the relationship between SR and academic achievement. This will contribute to a better understanding of the complexity of SR development and help determine whether SR should be a priority in ECE. Lastly, the study concludes that the relationships between children's abilities may be influenced by various factors, including the relationships that teachers establish with children and the developmental skills of children. From a practical perspective, we encourage teachers to prioritize positive interactions with children, creating a gender-inclusive classroom atmosphere and nurturing positive relationships with young children. Moreover, educators should provide activities aimed at improving children's SR and SE during K1. This approach can maximize the cumulative effects of closeness TCR, SR, and SE, ultimately enhancing their impact on academic achievement.

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