Preschoolers’ language skills and inhibitory control: The role of classroom engagement

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The preschool year is a critical time when children make substantial growth in their language skills and inhibitory control, both of which are cornerstones of children’s school readiness (Justice et al., 2009; McClelland et al., 2007). However, due to disparities in early learning resources, individual differences in both language and inhibitory control domains exist before children enter preschool and remain stable or even widen over time (Feinstein, 2003; Merz et al., 2019). Recent research has established that children’s abilities in these domains at the start of preschool shape both their short-term and long-term development (Bohlmann et al., 2015; Fuhs & Day, 2011). However, less is known about the pathways that sustain these developmental patterns. One pathway through which these differences in level of preschool entry skills matter may be the ways in which they shape children’s individual engagement within the classroom with three essential development resources - their teachers, peers, and tasks (Downer et al., 2010).

From a bioecological perspective, children’s initial level of language skills and self-regulation when they enter preschool lay the foundation for how they approach their teachers, peers, and tasks as well as how their classroom environment respond to them (Bronfenbrenner & Morris, 2006). These engagement patterns may in turn predict the quantity and quality of their learning in the embedded classroom environment for skills growth (Howes, 2000). Accordingly, this study examines: 1) the extent to which initial vocabulary and inhibitory control at the entry of the preschool year predict children’s classroom engagement observed during the preschool
year; and 2) the extent to which children’s classroom engagement mediates the associations between their preschool-entry and preschool-exit vocabulary and inhibitory control.

**Theoretical framework**

This study is built upon the bioecological model (Bronfenbrenner & Morris, 2006), which highlights the transactional relations between children’s individual skills and their engagement with teacher, peers, and tasks over time. According to the bioecological model, individual children are affected by the initiated behaviors and responses from the proximal environment they are directly exposed to and interact with. Meanwhile, children’s preexisting characteristics partly select with whom or what they choose to interact and how they interact with them, as well as lead changes in their interacted environment. Children’s individual characteristics and their interactional context interplay over time to shape different developmental patterns. Applying these insights to the current study, as preschoolers significant amounts of time in classrooms, their social interactions with their teacher and peers in conjunction with their physical interactions with objects may function as proximal processes predicting their developmental outcomes (Vygotsky, 1978). How these proximal processes impact skill gains vary systematically as a joint function of the characteristics of children’s individual development and changing classroom context across the preschool year. Specifically, children’s initial language skills and inhibitory control contribute to how they select and shape their interactions with the teacher, peers, and tasks within the classroom and how these classroom elements respond to them. Furthermore, how children are engaged with their teachers, peers, and tasks predicts the skills they learn within classrooms, which in turn, contributes to the gains in language and inhibitory control.

**Development of early language skills and inhibitory control**
Children’s language skills rapidly increase and become more complex during the preschool year; they acquire and start to use more expressive vocabulary to communicate their needs and thoughts with others (Hoff et al., 2014; McCarthy, 1943). Furthermore, preschoolers’ vocabulary functions as a strong predictor for other several academic outcomes (i.e., reading, literacy, math) as well as social behavioral outcomes (i.e., social skills, externalizing behavioral problems) in later years (Estrem, 2005; Justice et al., 2009). Likewise, inhibitory control, the ability to suppress an incorrect predominant or salient response to irrelevant or disturbing information in order to execute subdominant whereas correct behaviors, is also widely recognized as a critical developmental marker (Diamond, 2013). Inhibitory control demonstrates rapid growth during preschool years, with the shift from externally controlled response to internally based discipline (Clark et al., 2013; Macdonald et al., 2014). Children entering formal schooling without adequate inhibitory control are at greater risk for low levels of academic achievement (McClelland et al., 2007), as well as poor social skills and relationships with peers and teachers (Rhoades et al., 2009).

Emerging studies examining the co-development of language skill and inhibitory control suggest possible bidirectional relations between vocabulary gains and change in inhibitory control over time (Bohlmann et al., 2015; Cadima et al., 2019; Fuhs & Day, 2011; Slot & von Suchodoletz, 2018; Weiland et al., 2014). Better self-regulation facilitates children’s sustained engagement in conversations and learning activities by blocking distractions, which enables them to efficiently internalize the inputted vocabulary and actively practice vocabulary (Bohlmann et al., 2015). Reciprocally, higher language skills also facilitate the transition from other- to self-regulation through the use of self-talk to reflect and monitor their actions according to certain rules or goals (Fuhs & Day, 2011; Vygotsky, 1978). The important role of early language skills
and inhibitory control and the potential interrelations between them calls for more nuanced studies to untangle the mechanisms explaining the within domain and cross-domain effects of school-entry skills.

**Children’s classroom engagement**

One potential factor that links school-entry language skills and inhibitory control with later skill gains might be children’s individualized experiences within the classroom. Looking beyond the ‘average’ classroom experience as measured by overall structural and process quality of classroom, individualized classroom experiences captures how individual children experience and benefit from the same classroom differently in a more nuanced way (Howes, 2000). Therefore, individual classroom experiences has been viewed as a key proximal process that matters for early learning and development (Burchinal, 2021; Chien et al., 2010; Sabol et al., 2018). In support of this assertion, an emerging body of research suggested that the amount and complexity of conversation with teacher vary greatly among children within the same classroom (Burchinal, 2021; Sawyer et al., 2018).

One important aspect of children’s individualized experiences is their engagement in the classroom. As stated earlier, children’s teacher, peers, and tasks are the main classroom resources for children’s learning (Vygotsky, 1978). Children engage with these developmental resources in positive and negative ways, which lead to different learning outcomes (McEvoy et al., 2003). As such, previous studies have determined four distinct dimensions to reflect children’s classroom engagement (Bohlmann & Downer, 2016; Sabol et al., 2018). The first one is positive engagement with teachers, which captures children’s behavior patterns in seeking proximity and positive communication with their teacher. The second is positive engagement with peers, referring that children actively and successfully initiate and maintain conversation
and play with classmates. The third is positive engagement with tasks, which captures the degree to which children remain focused on classroom activities and actively make best use of these activities. The last is negative classroom engagement, including children’s conflict with teachers and peers and their display of off-task and interrupted behaviors (Downer et al., 2010). Taken together, these four dimensions of engagement jointly characterize children’s interaction patterns with the classroom setting.

**The relation of initial language and inhibitory with children’s classroom engagement**

Given the emerging evidence supporting the important role of children’s classroom engagement, the factors that shape children’s classroom engagement have gained increasing attention (V. E. Vitiello et al., 2012; V. E. Vitiello & Williford, 2020). In this study, we postulate children’s preschool-entry language and inhibitory control may have ramifications for their classroom engagement during the preschool year. The reasons for focusing on preschoolers’ school-entry skills are first because prior research has shown that a significant portion of variance in classroom engagement was due to differences between children, as opposed to classroom-level differences (V. E. Vitiello et al., 2012). Second, exploring school-entry skills as predictors of children’s engagement helps explaining why differences in school-entry skills remain stable or widen within domain and cross domain across preschool years.

As a psychological tool for higher-order symbolizing and thinking, enriched and appropriate expressive vocabulary allows children to articulate their needs and thoughts through appropriate requesting, commenting, and help-seeking from teachers (Rimm-Kaufman et al., 2009). Children with more advanced expressive vocabulary are also more capable in coordinating the planning and maintenance of peer play, as well as negotiating conflict with peers (Mendez et al., 2002; Mulvey & Jenkins, 2020). In contrast, children with limited
expressive vocabulary have a higher tendency to display physically aggressive behaviors due to the incapability of effective communications with others (Dionne et al., 2003; Grünigen et al., 2010). For example, Cadima and colleagues (2019) found children’s higher level of school-entry vocabulary contribute to the closeness with teachers, which might indicate more positive interpersonal engagement. Moreover, language skills, especially self-talk, also function as a mental tool for children to maintain attention and process information by representing the objects and strategies with abstract vocabulary and sentences, so that they can orient themselves toward the requirement and goal of their assigned tasks (Fernyhough & Fradley, 2005; Manning et al., 1994; Vygotsky, 1978). On the contrary, the early language failure or difficulties can trigger frustration and avoidance in learning activities, resulting in the high frequency of off-task behavior (Guo et al., 2015).

Inhibitory control reflects children’s ability to regulate their behaviors to comply with social norms or contextual requirements, which might facilitate or undermine engagement with their teacher, peers, and tasks. Children with better developed inhibitory control tends to interact and response to others in a more socially desired way, which can contribute to a high-quality relationship with teachers and peers (Portilla et al., 2014; Willoughby et al., 2011). Teachers are also more inclined to initiate positive interaction with well-regulated children and apply more behavioral intervention with poor-regulated children, especially in teacher-directed activities (Robson, 2016). Meanwhile, well-regulated children are more self-determined and efficient in remaining focused on a given activity instead of being distracted by irrelevant and disturbing events (Cadima et al., 2015; Moffett & Morrison, 2020). For example, using a different cohort from the the National Center for Research on Early Childhood Education (NCRECE) Teacher Professional Development Study (PDS), Bohlmann and Downer (2016) found inhibitory control
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was directly associated with sustained and active engagement with tasks and activities observed in the classroom.

With prior studies shedding lights on the pathway from school-entry language skills and inhibitory control to children’s classroom engagement, children’s classroom engagement with teachers, peers, and tasks have also been demonstrated each as unique predictor for their early school success, including their language and inhibitory control development (Bohlmann & Downer, 2016; Sabol et al., 2018; V. Vitiello & Williford, 2016). Importantly, these associations are over and above the effects of global classroom quality (Sabol et al., 2018). Children who engage more positively with their teachers, peers, and tasks experience more dyadic conversations, richer language input, and more individualized and self-regulated learning (Justice et al., 2013; Liew et al., 2010; Palermo et al., 2007), all of which are key for their language learning (Hamre & Pianta, 2001; Sabol et al., 2018). Additionally, more positive engagement with teachers and peers provide children with opportunities to experience different perspectives of view from others, which may facilitate their own behavioral regulation (Cadima et al., 2015; Sabol et al., 2018). In contrast, children’s negative engagement with teachers, peers, and tasks has been found to result in fewer opportunities for children to participate in activities that involve explicit or implicit language learning as well as a more interrupted environment for practicing inhibiting behavior (Sabol et al., 2018; Williford et al., 2013). These studies taken together suggests that children’s classroom engagement might play a critical role in explaining the interalations of language and inhibitory control development over time.

The Current Study

The extant literature reviewed above suggests that children’s development in language skill and inhibitory control and their classroom engagement mutually influence one another over
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time. This hypothesis is supported by the recent studies examining the dynamic interrelations between children’s skills and proximal interaction process with classroom environment (Bohlmann & Downer, 2016; Cadima et al., 2019). We will add to these studies by 1) examining children’s interpersonal interaction with their teacher and peers and physical interactions with tasks, and 2) examining the cross-domain and within-domain association between vocabulary and inhibitory control through these individual classroom experiences. Exploring the interplay of language skills and inhibitory control to explain the variation in different aspects of classroom engagement and the mechanism linking the interrelation between language skill and inhibitory control will lead evidence to support the bioecological model as well as inform the optimization of classroom experiences for children entering classrooms with different level of skills.

Method

Participants

Participants for this study were drawn from the Teacher Professional Development Study conducted by the NCRECE (Hamre et al., 2012; Pianta et al., 2017). This randomized control project aimed at developing teachers’ skills in didactic interaction with children through two intervention conditions in two sequential years, including a coursework intervention in year 1 and a consultation support intervention in year 2. In year 3, a post-intervention follow-up was executed to collect data only without any treatment. Teachers were recruited from large community preschools and Head Start programs across ten locations in eight states after attending recruitment meetings. To be considered eligible for participation in the PDS, teachers and classrooms had to meet the following criteria: teachers taught in a publicly- funded classroom and used English for most of instruction and the majority of children in the classroom were going to attend kindergarten in the following year and didn’t have an IEP. In each
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consented classroom, an average of 4 children were select to participate in the observation and assessment according to a specific protocol, with the preference given to 4-year-olds.

Given that year 2 ($M = 1.86$ children) had fewer observed children in each classroom than year 3 ($M = 4.01$ children) and year 1 has no child assessment data, a total of 895 children (443 girls, 452 boys; mean age=4.11 years, $SD=0.50$) across 223 classrooms in year 3 were used for the following analysis. Most participating teachers in year 3 had at least a Bachelor’s degree and had taught for 8.42 years on average. The participating children were diverse in terms of race (Black/African American, 42.20%; White, 13.53%; Latinx, 35.21%; other, 9.06%) and primarily came from a low-SES background, with the average annual household incomes being $23,948 ($SD = 22,440) and an average maternal education of 12.70 ($SD = 2.35$) years. More detailed descriptive information is shown in Table 1.

**Measures**

**Vocabulary.** The Picture Vocabulary subset of the Woodcock-Johnson-III Psychoeducational Battery (WJ–III; Woodcock, 2001) was used to measure children’s expressive vocabulary at the beginning and at the end of the preschool year. In this test, children were asked to name the presented objects in the given pictures, with the number of correct answers scored as their expressive vocabulary level. The WJ–III demonstrated good reliability ($\alpha = .81$) and construct validity (Woodcock, 2001). In order to compare expressive vocabulary of assessed children’s with their same-aged peers in the population, the standardized scores of the WJ–III were used for the following analysis.

**Inhibitory control.** The Pencil Tap test was chosen to assess children’s inhibitory control (Smith-Donald et al., 2007). Children were instructed to inhibit their dominant response and display the required response by tapping once when the assessor taps twice and vice versa. Percent
of correct responses out of 16 trials were used as the final score in following analysis. To complete this test, children need to be able to sustain or shift attention to retain the instructed information and handle conflict stimuli, as well as control the irrelevant or incorrect response. The Pencil Tap Test has been demonstrated good concurrent and construct validity (Smith-Donald et al., 2007).

*Classroom engagement.* Children’s individual engagement with teachers, peers, and tasks within the preschool classroom was observed and rated using the Individualized Classroom Assessment Scoring System (inCLASS; Downer et al., 2010). The inCLASS originally contained nine dimensions: (a) positive engagement with teachers; (b) communication with teachers; (c) conflict with teachers; (d) sociability with peers; (e) assertiveness with peers; (f) communication with peers; (g) conflict with peers; (h) engagement with tasks; (i) self-reliance with tasks; and (j) behavior control was added as the tenth dimension according to the initial psychometric study. Children’s behaviors were rated based on a set of behavioral indicators suggesting low, medium, and high quality for each dimension. Observers were trained to rate using a seven-point scale. Except that (c) conflict with teachers and (g) conflict with peers have higher ratings indicating higher negative engagement level; for the rest of dimensions, 6-7 indicates high quality, 3-5 indicates moderate quality, and 1-2 indicates low quality (Downer et al., 2011).

Four conceptually and empirically valid factors were emerged in previous factor exploratory analysis using racially, linguistically, and socioeconomically diverse samples: Positive engagement with teachers (positive engagement and communication with teachers); positive engagement with peers (sociability, assertiveness, and communication with peers); positive engagement with tasks (engagement and self-reliance with tasks); and negative classroom engagement (conflict with teachers and peers, reverse scored behavior control).
In the current study, all four factors showed high internal consistencies ($\alpha = .99$ across individual factors and overall scale). Each child was observed four 15-min cycles by two independent well-trained raters. The inter-rater reliability among these two raters was satisfactory (ranging from 0.71 to 0.99 for the four factors); the intra-class correlations (ICCs) across all dimensions also demonstrated good reliability (0.84; Downer et al., 2010). We averaged the ratings across the two raters as the scores of children’s engagement in the following analysis.

Covariates. We controlled a set of child-level covariates to reduce the possibility of obtaining spurious associations, including child age, gender, race/ethnicity, maternal education, the time between pre and post-test whether the child is an English language learner. All these covariates have been demonstrated to relate with children’s expressive vocabulary and inhibitory control, and classroom engagement (Vitiello et al., 2012). In addition, whether teachers’ received the intervention or control condition in Phase 1 and Phase 2, and the site location of programs were also included as covariates.

Analytic Approach

Data were analyzed in Mplus 7.4 within a path analytic framework (Muthén & Muthén, 2015). The examination of missing data suggested that some cases have missing data on the analyzed variables, with the percentage ranging from 7-58%. This amount of missing data are common in longitudinal studies targeting preschoolers due to their high risk of attrition and absences. Further exploration of the correlations between missingness within the data indicated the high possibility of missing at random, even though Little’s MACR test suggested that the missing data were not missing completely at random ($\chi^2 (5263) = 6636.1080, p < 0.001$). The missingness of children’s post expressive vocabulary was found to be correlated with household
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income and child race; and the missing of children’s post inhibitory control depended on household income. To reduce the biased estimation of parameters and the possibility of losing statistical power, we performed full-information maximum likelihood estimation (FIML) to account for the missing data. By including the related auxiliary variables and utilizing all the available information from each case to do the estimation, the use of FIML ensured less biased results. To account for children nested in classrooms, standard errors were clustered at the classroom level.

We first ran an autoregressive cross-lagged model to examine the bidirectional associations between expressive vocabulary and inhibitory control. Then, to answer the first research question, we conducted a path model regressing the four classroom engagement variables on both children’s initial expressive vocabulary and inhibitory control. Finally, a path model examining the indirect effect of initial expressive vocabulary and inhibitory control on later skills through classroom engagement was executed by using the INDIRECT command in Mplus. For all models, the above-mentioned covariates were controlled. Since all continuous variables were standardized to have a mean of 0 and standard deviation of 1, all reported effect sizes below can be interpreted as standardized coefficients.

Results

To begin, we tested the bidirectional relations between vocabulary and inhibitory control. Both children’s fall vocabulary and inhibitory control were respectively associated with their vocabulary and inhibitory control in the spring (ES = .81, p < 0.001 for vocabulary; ES = .45, p < 0.001 for inhibitory control) (see Table 2). However, only preschool-entry vocabulary in the fall was significantly associated with year-of-end inhibitory control in the spring after controlling fall inhibitory control (ES = .21, p <0.001); inhibitory control at fall of the preschool year was not
associated with vocabulary in spring with vocabulary in fall controlled (ES = .00). This result failed to support the bidirectional relations between language skill and inhibitory control.

The associations of preschool-entry vocabulary and inhibitory control with classroom engagement

In a separate model, we examined the extent to which children’s classroom engagement varied depending on their vocabulary and inhibitory control in the fall. As shown in Table 3, results from this model suggested that children’s school entry vocabulary was associated with more positive engagement with their teachers and peers (ES = .15, p < 0.01; ES = .13, p < 0.05); whereas, children’s school entry inhibitory control was associated with greater task engagement as well as less conflict with teacher and peers, and less off-tasks behaviors (ES = .09, p < 0.05; ES = -.14, p < 0.01). The associations between preschool entry vocabulary and task engagement and negative engagement were not significant (ES = 0.10, 0.09); preschool entry inhibitory control was also not significantly associated with positive engagement with teacher and peers (ES = 0.01, 0.05).

The mediating role of classroom engagement between vocabulary and inhibitory control

To answer our second research question, we tested whether fall and spring vocabulary and inhibitory control were interrelated with each other through children’s classroom engagement. As shown in Table 3, children’s positive engagement with teacher was associated with greater gains in vocabulary (ES = .04, p < 0.05), whereas children’s negative engagement was associated with fewer gains in both vocabulary and inhibitory control (ES = -.04, p < 0.05; ES = -.11, p < 0.01). We only detected one indirect pathway between fall inhibitory control and spring inhibitory control through negative engagement (ES_{indirect} = -.02, p < 0.05), suggesting that
higher levels of fall inhibitory control was associated with lower negative engagement, which in turn, contributed to greater gains in inhibitory control through the spring.

**Discussion**

Understanding how preschoolers’ school-entry language and inhibitory control shape their later skill gains is critical as early development in these skills lay the foundation for later development in both these skills and others (Feinstein, 2003; Merz et al., 2019). Although we have begun to unravel the associations between early language skills and inhibitory control (Bohlmann et al., 2015; Fuhs & Day, 2011), the mechanisms that sustain this association over time are not well-understood. As children’s individual classroom experiences are a key process in their skills development (Howes, 2000), this study examined classroom engagement as both an outcome of children’s preschool-entry skills and a mediator of linkages between vocabulary and inhibitory control across the preschool year.

We found that children with stronger vocabulary skills at the start of the preschool year had more positive engagement with both their teachers and their peers. These findings are consistent with previous studies suggesting that higher language skills at school entry allow children to better communicate and interact with their teacher and peers and establish high quality relationships with them (Mendez et al., 2002; Rimm-Kaufman et al., 2009). Additionally, children with better inhibitory control had more positive engagement with tasks and less negative engagement in the classroom. This aligns with findings documenting that children with better developed inhibitory control are more capable in orienting themselves towards tasks and in reducing conflict with their teacher and peers (Berry, 2012; Moffett & Morrison, 2020; Rhoades et al., 2009). We extended previous studies by examining the two skill domains together and identifying their each unique role in shaping different aspects of children’s
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classroom engagement when holding the other one constant. The findings indicated that languages skills might specifically matter for children’s positive interpersonal interactions; while inhibitory control might specifically be related to children’s physical interactions with tasks and disruptive behaviors.

It is important to note our non-significant findings as well. First, vocabulary did not predict engagement with tasks or negative classroom engagement. This may be due to the fact that self-talk abilities, which can serve as mental tools to facilitate attention maintenance and behavioral regulation, are still under-developed for preschool children (Fuhs & Day, 2011). Therefore, the richness and complexity of children’s school-entry vocabulary doesn’t directly contribute to their better tasks engagement and reduced negative engagement. Second, the benefit of better-developed inhibitory control on initiating positive interactions with teacher and peers and receiving preferred response from them largely depend on children’s other characteristics (especially temperament), their teachers’ and peers’ likeness, and the specific activity contexts.

We also found that negative engagement mediates associations between school-entry and school-exit inhibitory control over and above their own direct association and the direct association between vocabulary and inhibitory control. A number of studies have examined the within-domain and cross-domain developmental patterns of language skills and inhibitory control (Bohlmann et al., 2015; Cadima et al., 2019; Fuhs & Day, 2011; Slot & von Suchodoletz, 2018; Weiland et al., 2014). We added to these studies by trying to introduce classroom engagement to fill the mechanism of these established developmental patterns. Our finding regarding the mediating role of negative engagement echoed the bioecological model, which implies the transactional relations between children’s individual characteristics and their
interactional context over time (Bronfenbrenner & Morris, 1998). Specifically, higher levels of inhibitory control at school entry has the potential to reduce children’s conflict with teacher and peers and off-task behaviors, which in turn, lend them more opportunities to learn others’ perspectives and expectations and provide them with more undisturbed environment to practice behavior inhibition. Previous studies tackling how young children’s skills intersect with their interaction with others within classroom also lend support to this finding (Berry, 2012; Bohlmann & Downer, 2016; Cadima et al., 2019). For example, using a sample of elementary-school children, Berry (2012) found lower levels of inhibitory control was subsequently associated with children’s higher levels of conflicts with teacher and inattention and aggression problems, which further lead to lower levels of inhibitory control.

However, the within domain pathway for vocabulary and cross-domain pathways between vocabulary and inhibitory control through classroom engagement were not significant in this study, which remind us to cautiously interpret the only one significant pathway. These nonsignificant pathways might be due to the lack of significant effect size of classroom engagement on children’s outcomes, which is inconsistent with the extant study generating considerably larger effect sizes of classroom engagement dimension on vocabulary and inhibitory control (|0.02–0.22|; Sabol et al., 2018). One thing worth to notice is that the data they used was also drawn from the same study with us, however, focused on one of the 10 sites with a more extensive observational protocol for each child within each classroom, which might lead to more accurate capture of classroom engagement components and larger effect size of them (Sabol et al., 2018). This comparison calls for more nuanced measures of children’s individual classroom engagement and more examination on the mediating role of other aspects of individual classroom experiences.
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Conclusion

In sum, this study demonstrated that children’s vocabulary at the school entry was associated with more positive engagement with teachers and peers. Meanwhile, higher levels of school-entry inhibitory control were associated with more task engagement and fewer conflicts with the teacher and peers, which were linked to higher subsequent levels of inhibitory control. Given the large amount of time that children spent in the classroom (Chien et al., 2010), these findings have implications for optimizing children’s language and inhibitory control development by improving teachers’ skills in minimizing the negative engagement of children with lower levels of school-entry skills.


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### Table 1. Descriptive Statistics of Focal Variables and Covariates for the Sample (n=895)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)/Percent</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beginning-of-year skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>94.07(19.20)</td>
<td>24</td>
<td>129</td>
</tr>
<tr>
<td>Inhibitory control</td>
<td>0.48(0.32)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>End-of-year skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>95.55(15.14)</td>
<td>22</td>
<td>132</td>
</tr>
<tr>
<td>Inhibitory control</td>
<td>0.61(0.32)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Individual classroom engagement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive engagement with teacher</td>
<td>2.21(0.84)</td>
<td>1</td>
<td>6.17</td>
</tr>
<tr>
<td>Positive engagement with peers</td>
<td>2.50(0.88)</td>
<td>1</td>
<td>6.56</td>
</tr>
<tr>
<td>Positive engagement with tasks</td>
<td>4.26(0.81)</td>
<td>1.83</td>
<td>6.50</td>
</tr>
<tr>
<td>Negative engagement</td>
<td>1.37(0.38)</td>
<td>1.00</td>
<td>3.67</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Child age</td>
<td>4.11(0.50)</td>
<td>2.26</td>
<td>5.38</td>
</tr>
<tr>
<td>Child gender: female</td>
<td>49.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Child race/ethnicity</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Black/African American</td>
<td>42.20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>13.53</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hispanic/Latinx</td>
<td>35.21</td>
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<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>9.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Household income/1,000</td>
<td>23.95(22.44)</td>
<td>2.50</td>
<td>87.50</td>
</tr>
<tr>
<td>Mothers’ education</td>
<td>12.70(2.35)</td>
<td>8.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Child language is English</td>
<td>84.42</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Intervention conditions in phase 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In year 1 intervention</td>
<td>41.89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Participated in year 1 control</td>
<td>40.54</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Added in year 2, not in year 1</td>
<td>17.57</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Intervention conditions in phase 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In year 2 intervention</td>
<td>50.45</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Participated in year 2 control</td>
<td>49.55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>895</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2.
The Association of Fall Vocabulary and Inhibitory Control with Individual Classroom Engagement and Spring Vocabulary and Inhibitory Control (n=895)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Fall vocabulary ES(SE)</th>
<th>Fall inhibitory control ES(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring vocabulary</td>
<td>0.81(0.04)***</td>
<td>0.21(0.05)***</td>
</tr>
<tr>
<td>Spring inhibitory control</td>
<td>0.00(0.02)</td>
<td>0.45(0.04)***</td>
</tr>
<tr>
<td>Individual classroom engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive engagement with teacher</td>
<td>0.15(0.06)**</td>
<td>0.01(0.04)</td>
</tr>
<tr>
<td>Positive engagement with peers</td>
<td>0.13(0.06)*</td>
<td>0.05(0.04)</td>
</tr>
<tr>
<td>Positive engagement with tasks</td>
<td>0.10(0.06)</td>
<td>0.09(0.05)*</td>
</tr>
<tr>
<td>Negative engagement</td>
<td>0.09(0.05)*</td>
<td>-0.14(0.04)**</td>
</tr>
</tbody>
</table>

Note. Models controlled for child-level covariates (age, gender, race/ethnicity, household income, maternal education, child language in English, and the time between pre and post-tests), the intervention conditions, and the site location.
The effect size here refers to the standardized coefficient, since all the continuous variables were standardized to have a mean of 0 and standard deviation of 1.
This table presents two separated model, with the first two outcomes (Spring vocabulary and spring inhibitory control) included in one model, and the rest of four subdimensions of individual classroom engagement included in the other model.
*p<0.05, **p<0.01, ***p<0.001, +p<0.10.
### Table 3.
**Direct and Indirect Coefficients for Classroom Engagement as Mediators of the Associations between Fall and Spring Vocabulary and Inhibitory Control (n=895)**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Outcome</th>
<th>ES(SE)</th>
<th>Inhibitory control</th>
<th>ES(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive engagement with teacher as the mediator</strong></td>
<td>Vocabulary</td>
<td>0.04(0.02)*</td>
<td>-0.04(0.03)</td>
<td></td>
</tr>
<tr>
<td>Teacher → child outcome</td>
<td>Inhibitory control</td>
<td>0.01(0.00)*</td>
<td>-0.01(0.01)</td>
<td></td>
</tr>
<tr>
<td>Spring vocabulary → teacher → child outcome</td>
<td></td>
<td>0.00(0.00)</td>
<td>0.00(0.00)</td>
<td></td>
</tr>
<tr>
<td>Spring inhibitory control → teacher → child outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Positive engagement with peers as the mediator</strong></td>
<td>Vocabulary</td>
<td>0.03(0.02)</td>
<td>0.06(0.04)</td>
<td></td>
</tr>
<tr>
<td>Peer → child outcome</td>
<td>Inhibitory control</td>
<td>0.00(0.00)</td>
<td>0.01(0.01)</td>
<td></td>
</tr>
<tr>
<td>Fall vocabulary → peer → child outcome</td>
<td></td>
<td>0.00(0.00)</td>
<td>0.00(0.00)</td>
<td></td>
</tr>
<tr>
<td>Fall inhibitory control → peer → child outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Positive engagement with tasks as the mediator</strong></td>
<td>Vocabulary</td>
<td>-0.03(0.03)</td>
<td>-0.03(0.05)</td>
<td></td>
</tr>
<tr>
<td>Tasks → child outcome</td>
<td>Inhibitory control</td>
<td>-0.00(0.00)</td>
<td>-0.00(0.01)</td>
<td></td>
</tr>
<tr>
<td>Fall vocabulary → task → child outcome</td>
<td></td>
<td>-0.00(0.00)</td>
<td>-0.00(0.01)</td>
<td></td>
</tr>
<tr>
<td>Fall inhibitory control → task → child outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Negative engagement as the mediator</strong></td>
<td>Vocabulary</td>
<td>-0.04(0.02)*</td>
<td>-0.11(0.04)**</td>
<td></td>
</tr>
<tr>
<td>Negative → child outcome</td>
<td>Inhibitory control</td>
<td>-0.00(0.00)</td>
<td>-0.01(0.01)</td>
<td></td>
</tr>
<tr>
<td>Fall vocabulary → negative → child outcome</td>
<td></td>
<td>0.05(0.00)</td>
<td>0.02(0.01)*</td>
<td></td>
</tr>
<tr>
<td>Fall inhibitory control → negative → child outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Models controlled for child-level covariates (age, gender, race/ethnicity, household income, maternal education, child language in English, and the time between pre and post-test), the intervention conditions, and the site location.

The effect size refers to the standardized coefficient, since all the continuous variables were standardized to have a mean of 0 and standard deviation of 1.

*p<0.05, **p<0.01, ***p<0.001, +p<0.10.*