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Preschool children's joint block building during a guided play activity

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ABSTRACT

Although children build in block areas both individually and jointly, little is known about the nature of children's behavior and communication in this play context with peers. We observed 4- and 5-year-old same-age, same-sex dyads ($n = 38$) during a guided play activity, which involved building a house with large colorful blocks. We analyzed children's communication and building behaviors, as well as the role of their coordinated behavior in the structures that they built. Children's spatial talk was associated with the features of a house included in structures, whereas children's building behavior was associated with the complexity of the structures. However, children's coordinated behavior during the interaction mediated the relations between spatial talk and the structures they built. Results are discussed in terms of the importance of encouraging joint guided block play activities in early childhood classrooms to provide children with opportunities to practice and expand their language, math, and spatial skills.

Play and informal learning activities can promote foundational skills and knowledge in young children. Playing with blocks, a popular activity found in most preschool and kindergarten classrooms, can contribute to children's early mathematical development, such as spatial reasoning, knowledge of geometric shapes, numerical knowledge, and problem-solving skills (Kamii, Miyakawa, & Kato, 2004; Ness & Farenga, 2007; Reifel & Greenfield, 1982; Seo & Ginsburg, 2004; Wellhousen & Kieff, 2001). Block play can also contribute to children's language and literacy skills (Cohen & Uhry, 2007; Stroud, 1995). The benefits of playing with blocks seem to have long-term implications. Children's block play during the preschool years has been associated with concurrent spatial skills, as well as later math achievement (Caldera et al., 1999; Stannard, Wolfgang, Jones, & Phelps, 2001; Wolfgang, Stannard, & Jones, 2001).

Young children in early childhood classrooms play with blocks both independently and collectively (Kersh, Casey, & Mercer Young, 2008); however, little is known about the nature of children's behavior and communication during block building with peers. Examining children's joint block play is critical for understanding both the cognitive and social benefits of playing with blocks. Thus, the current study examined preschool children's peer communication and building behaviors, as well as the role of their coordinated behavior with each other in the structures that they built during a guided play block building activity.

Block building during the preschool years

Children's ability to create sophisticated structures with blocks develops during the preschool and school-age years. Reifel and Greenfield (1982) describe how the spatial relations within children's buildings, defined as "the dimensionality" and "hierarchical integration of block constructions," become more complex with age. Structures of toddlers and young preschoolers are typically limited in their spatial dimensionality, with structures being mainly composed of a single block or several blocks simply placed next to each other, such as in a row or tower. During the later preschool years and into early elementary school, children will arrange multiple blocks to create arch or bridge structures by placing two or more blocks vertically and placing another block on top. Children also create enclosures with the open spaces representing a part of the building (Goodson, 1982; Sluss, 2002). Children then integrate these different aspects together to build increasingly complex structures. Even within the preschool years, block building becomes more sophisticated, with 4-year-olds focusing on placing blocks on top of one another to make towers and posts, and 5-year-olds attending to complex features of the structures, such as its symmetry and patterns (Ness & Farenga, 2007).

These advancements in young children's block building behavior are supported by and can contribute to the development of children's math and spatial abilities. For example, integrating different building aspects together is likely related to the development of the understanding of part–whole relationships (Gura, 1992). Kamii et al. (2004) suggest that building and manipulating blocks provide numerous opportunities for children to explore and develop their logical–mathematical knowledge, theorized by Piaget (1950) to include skills such as classification, seriation, spatial relations, and number. When children arrange blocks of the same size, shape, color, and orientation together, they are sorting and classifying, as well as exploring concepts related to congruence, equivalence, and patterning (Kersh et al., 2008). Thus, block play can foster children's development, as well as contribute to more advanced building.

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Children's joint block play with peers

Several theoretical approaches posit that peer interactions, and play, in general, are critical for children's development. Piaget (1962) suggested that play provides children with opportunities to interact with materials around them that assist in constructing their knowledge of the world. Piaget (1932) also suggested that when peers of equal ability solve problems together, they must understand each other's views to reach a joint solution. Through discussion, children attempt to resolve their differing perspectives and advance their understanding of difficult problems. Contemporary theorists and researchers also describe that during playful interactions with peers, children practice and utilize advanced social and cognitive skills to create, sustain, and fulfill joint goals. According to Pellegrini (2009), during peer play, children must coordinate their behaviors, communicate effectively to establish the goals and rules of the interaction, and work through any disagreements. Children's ability to coordinate their behavior with a peer by monitoring and accommodating their behavior to one another and their joint goal is an important milestone in the development of peer cooperation (Brownell, Ramani, & Zerwas, 2006; Eckerman & Peterman, 2001). Tomasello (2009) hypothesizes that successful cooperation requires that both children have a mutual understanding of these shared goals and the processes to achieve them. Joint cooperative activities are characterized by this common understanding of the goals, behaviors, and processes necessary to meet them (Bratman, 1992).

Children's abilities to coordinate behavior to complete joint goals with a peer emerge during toddlerhood and develop during the preschool years. During the toddler years, children begin engaging in joint activities with peers (Eckerman & Peterman, 2001). On cooperative tasks that required one child to manipulate a lever on a toy to release a reward, while the other child retrieved it, 18-month-old dyads only occasionally solved the problem, typically accidentally and unsystematically, whereas 24-month-olds were consistently successful at retrieving the reward (Brownell & Carriger, 1990, 1991). Brownell et al. (2006) found similar age differences on a simpler cooperative task that required children to pull two handles to receive a reward. On a slightly more complex task that required children to both coordinate complementary roles, 2-year-old dyads were not successful, whereas 3½-year-old dyads were consistently able to coordinate their actions and language to retrieve a prize (Ashley & Tomasello, 1998). Further, 3.5-year-olds are able to commit to joint goals and assist their partner in retrieving a reward during a problem-solving task, even after they have retrieved their own (Hamann, Warneken, & Tomasello, 2012). On joint problem-solving tasks, young children can coordinate their behaviors, work together with a peer, and commit to joint goals.

Although the majority of research on block play has focused on the building complexity of individual children, block building with a peer can have additional benefits for children, such as providing opportunities to coordinate behavior with peers and establish joint building goals. Working with a peer likely allows children to create more complex structures than they would be able to complete alone, because they can each contribute to the building. Furthermore, joint building requires that children create and establish joint goals, such as what they are going to build and how they are going to build it. Similar to dramatic play, block play can also involve elements of pretense, which requires peers to communicate the meanings of their actions, the symbolic representations of the blocks, and the significance of the structures they create (Reifel & Yeatman, 1991). Thus, block building could provide an important play context to observe children creating, negotiating, and working towards completing shared building goals with peers.

Fewer studies, however, have examined children's coordinated behavior and peer communication during block building. Cohen and Uhry (2007) observed individuals, dyads, and small groups of children in the block play area of a preschool classroom. As would be expected, dyads and small groups talked more than children building by themselves, with peers often describing the ongoing activities, past actions, or future plans. Reifel and Yeatman's (1991) observation of preschool children's talk during block play showed that children worked together to form ideas about what to build, created symbolic meanings of the blocks, and developed solutions to problems. Sluss and Stremmel (2004) observed preschool dyads and found that girls built more complex structures and communicated more when paired with a more experienced social partner. Thus, working with a partner during block play elicits talk that could contribute to children gaining valuable linguistic skills during block play.

Communication between peers during block building could also elicit important discussion of mathematical and spatial concepts, although little is known about this type of talk in young children. Building a structure with a peer could involve talk related to numbers (e.g., "Put three blocks in the tower."), geometry (e.g., "The square goes here."), or spatial relations (e.g., "Turn the block around."). Engaging in math- and spatial talk can be critical for promoting early mathematical knowledge. For example, parent's spatial language has been shown to be related to children's spatial abilities, and these relations are mediated by the child's own spatial language (Pruden, Levine, & Huttenlocher, 2011). Language about how objects in a space are related to one another can facilitate spatial thinking by providing children with labels for reasoning about spatial relations and patterns (Gentner & Loewenstein, 2002). Thus, engaging in joint block play can benefit children through two processes: Physical manipulation of blocks and collaboration with related peer talk during the interaction. Each of these processes appears critical for gaining important social and cognitive skills.

Guided play block building activities

The nature of block building activities can provide insight into varying aspects of children's spatial and building skills. For example, the complexity of 3- to 5-year-olds' free play or unstructured block building was associated with a measure of creativity; however, their structured block play, which involved copying a complex block structure, was related to their performance on a measure of spatial visualization (Caldera et al., 1999). This suggests that different kinds of block play activities may require different skills and tap into different abilities.

One type of activity that is especially important during block play is guided play. Guided play involves activities that are enjoyable, but also provide opportunities for exploration and learning. These activities "are subtly directive, embedding new learning into meaningful contexts that correspond with children's prior knowledge and experience" (Hirsh-Pasek, Golinkoff, Berk, & Singer, 2009, p. 27). Guided play is being used increasingly in early childhood classrooms as a way to engage children in play activities that can connect to the curriculum and promote learning. For example, Casey et al. (2008) found that a guided block play intervention promoted preschool children's spatial skills. Specifically, children were told a story about characters in a book that needed a new castle and specified the elements to include in the structure. They found that children who engaged in the guided play activities with a group of children or alone built more complex buildings and showed greater improvement on spatial reasoning tasks than children who simply engaged in free play with blocks.

Guided play activities also may help to better understand the nature of gender differences in block building. Gender differences have been found in the complexity of children's structures during free play with blocks. Specifically, preschool- and kindergarten-aged boys built structures that are more similar to towers, whereas same-age girls built structures with more enclosures (Goodfader, 1982; Sluss, 2002). One hypothesis is that preschool-age boys have an advantage over same-age girls on spatial tasks that require spatial visualization and mental rotation of objects (Levine, Huttenlocher, Taylor, & Langrock, 1999; Rosser, Ensing, Gilder, & Lane, 1984). However, gender differences are likely influenced by the nature of the block building activity (Kersh et al., 2008). Although gender differences are found during unstructured block play, when children are provided with guided play building activities, comparable effects are not found. For example, when preschool children used blocks to act out a story previously read to them, no gender differences in 4- and 7-year-old children were found (Reifel & Greenfield, 1982). Gender differences were also not found in the children's buildings during the guided block play intervention used to promote children's spatial skills that was previously described (Casey et al., 2008). Together, this suggests that girls may benefit from activities that provide guidance and suggestions for their block building.

The current study

The purpose of the present study was to examine preschool children's communication, building behaviors, and coordinated actions with a peer partner during a joint guided play block building activity, as well as how these processes related to the structures that children built. Children were asked to build a house with several components, but were not given explicit directions on how to complete the house. This guided play activity was chosen to elicit coordinated behavior and talk between peers because it required children to discuss how they were going to complete the joint goal given to them.

The present study had four goals. The first goal was to examine the types of talk and building behavior children engaged in during block play with a peer. Previous work on block play has focused primarily on the complexity of children's structures (see Kersh et al., 2008 for review); however, these studies do not necessarily capture *how* children manipulate blocks during their building interaction, or children's communication while building with a peer. This study attempts to fill this gap in the literature by examining children's building behavior during a block building activity, as well as preschoolers' communication during the interactions.

The second goal was to examine gender differences in children's talk, building behavior, and structures. Although others have not found gender differences in the complexity of children's building following guided block play activities, it may be that boys and girls focus on different aspects of the building which are not captured in these ratings. Therefore, we examined whether there were gender differences in the two different measures of the structures: 1) the complexity of their building, such as the rows and towers they built; and 2) the symbolic features of their house they created, such as the door and walls. Typically children's block building has only been examined in terms of the complexity of their final structures, rather than what those structures represent symbolically. We also examined whether there were gender differences in peer communication and building behaviors during the interaction, which could contribute to differences in the structures that children built.

The third goal was to examine how children's talk, building behavior, and structures were related. Specifically, we were interested in how children's talk and building behavior related to different aspects of their structures. Examining the complexity as well as the features of house included in the structures could be important, such as providing insight into different ways children learn from block play (Kersh et al., 2008; Reifel & Greenfield, 1982). We also examined whether children's talk and building behavior were distinct processes that could each contribute uniquely to the structures that children built. We examined whether children's talk related to the features of a house they included in their structures because it would require discussion with the peer about the symbolic representations and placements of the blocks. We also examined whether children's building behavior related to the complexity of their structures, because building rows, column, and bridges would require advanced building skills and manipulation of the blocks.

The fourth goal was to examine how children's coordinated behavior played a role in the structures that they built. Specifically, we used the amount of time children coordinated their movements and actions with their partner as a nonverbal measure of peer cooperation, because language skills in young children can vary widely (Ashley & Tomasello, 1998; Brownell et al., 2006). We were interested in how much children coordinated their behavior with one another, because little is known about joint block play. We also were interested in whether the amount of time children engaged in coordinated behavior mediated any relations among children's communication, building behavior, and the structures children built. For example, it is possible that children who engaged in advanced building behavior or communication during the interaction built a more complex structure; however, these relations may be explained by how much they coordinated their behavior. Specifically, coordinated behavior may be important for creating complex structures, where children must both place blocks to integrate different components together. It is also possible that children's coordinated behavior is more important for some aspects of children's structures. That is, it may be more important for children to coordinate their behavior to create the structural features of the house, because joint goals would be needed to create these features. Understanding the role of coordinated action could provide insight into how much and when working together is important during block play.

Methods

Participants

Participants were 76 preschool children: Forty 4-year-olds ($M =$ 4 years 5 months, $SD = 0.30$; with 50% girls) and thirty-six 5-year-olds ($M =$ 5 years 4 months, $SD = 0.23$; with 50% girls). Children were recruited primarily from child-care centers in a medium-sized city. The centers serve families who are predominantly middle class; 87% were Caucasian, 10% Asian, and 3% Hispanic. Participants were recruited for a larger study on peer cooperation that involved two sessions (Ramani, 2012). Children's interactions from the first of these sessions were re-coded for the present study.

Overview of procedure

Children were paired with a familiar peer of the same age and gender, but not their best friends. Experimenters asked the children to name their three best friends or three children they liked to play with the most. Experimenters also asked a classroom teacher to name each of the children's three best friends and three children that the child did not get along with. Peers who were reported by the children and their teachers to be best friends, or peers who did not get along, were not paired together for the dyadic interaction. The children also had to know each other for at least one month to be paired together.

Children were tested in a room provided by their school or in their classrooms separated by bookshelves and tables from the ongoing activities in the larger room. All of the children's interactions were videotaped by an experimenter who sat silently in the corner doing paperwork during the interaction. The video camera was placed unobtrusively in a corner approximately 3 ft away from the carpet where the interactions took place, with a full view of the children, the blocks, and the structures. An external microphone was mounted in a block and placed unobtrusively next to the carpet to capture children's verbal communications.

Children were presented with a dyadic building task during a visit that lasted 10–15 min. Dyads were asked to build their structures on a carpet, approximately 1.4 m × 1.4 m. For the building task, children used a set of 65 multi-colored, age-appropriate cardboard building blocks of various sizes (largest blocks: 30.5 cm × 15.2 cm × 7.6 cm; smallest blocks: 7.6 cm × 7.6 cm × 7.6 cm) kept in a clear plastic box, and placed directly next to the carpet before the session. See Fig. 1 for a picture of the blocks, carpet, and an example of a structure.

Block building activity

Dyads engaged in a joint building activity for eight minutes. An experimenter asked the children to sit on the carpet and explained to them they were going to build something with the blocks. The

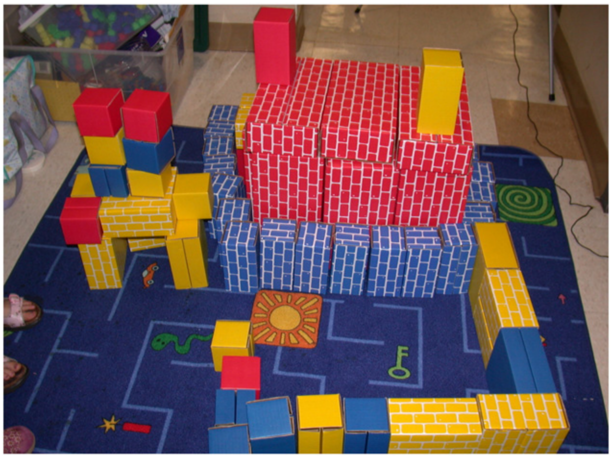

Fig. 1. Example of a house structure.

experimenter told the children that she wanted them to build a house, and that it should include some things that other houses have. Specifically, the children were asked to build a house that included four walls, a way to get inside the house (like a door), and at least two rooms. Dyads were not explicitly told to work together. The activity was a guided play activity because the children were given a goal, but could complete the goal in multiple ways with the experimenter minimally involved. The dyads were also told that they would have 8 min to finish their house. If they finished building their house before the time, dyads were to inform the experimenter they were finished building. After giving the instructions, the experimenter remained uninvolved; the only exception was that the experimenter let the children know when half of the session was over. If the dyads engaged the experimenter, she encouraged the children to continue building with the blocks. If dyads had not finished their building by eight minutes, the experimenter ended the session. The experimenter then took 5 to 6 pictures of the house, typically one picture of each side of the house and one view from the top. The experimenter then asked the dyads to describe the house using standard questions and prompts.

Peer communication, building behavior, and structures coding

Children's talk and behavior were coded from videotapes using the Noldus™ Observer 9.0 computer based observation software. Children's coordinated action was coded in total number of seconds across the interaction. All of the other children's behaviors were coded in 15-second intervals. Every interval was coded for whether there was any talking or building behavior. For every interval with a talking and building behavior present, it was further differentiated based on the coding scheme outlined below. Specific behavior and talk codes were not mutually exclusive within an interval with the exception of two communication codes described below. Inter-observer reliability was established between two independent observers, who were extensively trained by the second author. Each observer independently coded 10 of the interactions (26% of the interactions) equally distributed over age and gender. Kappa coefficients were not calculated because individual behaviors in the coding system were not mutually exclusive, which is an assumption required for determining Kappas (Agresti, 1996; Bakeman, 2000; Bruckner & Yoder, 2006). Therefore, intraclass correlations (ICCs) were calculated for each of the codes, which is the preferred method to calculate inter-observer reliability when Kappa coefficients cannot be calculated (McGraw & Wong, 1996). ICCs equal to or greater than 0.70 are considered acceptable levels of reliability (Ostrov & Hart, 2012).

Peer communication

The total number of intervals with talk was coded. For each of the intervals it was determined whether the children were engaging in task-related talk, talk not related to the task, or talk to the experimenter. All task-related talk was coded into the following measures. Codes were adapted from Reifel and Greenfield (1982) and Seo and Ginsburg (2004). The variables with their definitions and examples are presented in Table 1. The talk codes were *Symbol*, *Structural design*, which is a composite of design and restructuring, *Quantity*, which is a composite of number and time-related references, and *Spatial*, which is a composite of spatial arrangement and size or dimensions. Codes were not mutually exclusive. For example, a statement such as "I'm going to put more blocks," received a code for both structural design and quantity, with the one exception that if a design statement made reference to a symbolic representation of a block (e.g., "I'm making a door."), then it was only coded as symbol. Inter-observer reliability was calculated for each of the individual communication codes with ICCs ranging from .81 to .98.

We were interested in two different measures of children's talk. First, we were interested in the amount of task-related talk that children engaged in during the interaction. Because there was variation among dyads in the amount of overall talk, for this measure we calculated the proportions of both intervals with task-related and non-task-related talk, with the total number of intervals with any kind of talk as the denominator for both proportions. Second, we were interested in the kinds of talk that children engaged in that was related to the task, therefore, we calculated four proportions for each of the communication measures (i.e., symbol, structural design, quantity, and spatial) with the number of intervals with task-related talk as the denominator.

Building behavior

For each of the intervals, it was determined whether the children were engaging in off-task or on-task behavior. When children were on-task, the following building behaviors were coded based on children's placement of each block: *Vertical placements* (e.g. creating or adding to an existing column), *Horizontal placements* (e.g., creating or adding to an existing row), and *Creating bridges* (e.g., two blocks placed parallel to one another with a space between them and another block placed on top over the space). We examined each of these measures separately as they represent a developmental progression of complex block building behavior (Reifel & Greenfield, 1982). *Block matching* was a composite of two codes: 1) blocks that matched in size to an adjacent block, and 2) blocks that matched in orientation to an adjacent block. Codes were not mutually exclusive. Inter-observer reliability was calculated for each of the individual building codes with ICCs ranging from .72 to .95.

We were interested in understanding across children's building behavior what were the types of building children engaged in during the interaction. Therefore, we created a composite variable representing the total number of intervals in which building behaviors occurred for each child. We then calculated a proportion for each of the four building behaviors with the sum of the total number of intervals with building behaviors included as the denominator.

Coordinated action

The total time a child attempted to coordinate activity with their partner through physical movements was coded as coordinated action. An example would include the time during which one partner took a block out of the box and handed it to the other child to place on the structure. This also included helping behaviors where a child offered and/or provided the partner physical assistance in relation to completing the task, such as helping with balancing a block on top of another block. This behavior was not coded using intervals because we were interested in the total time children coordinated their behavior rather than just instances of coordinated action. A proportion of the total coordinated action was calculated with the duration of the entire session in seconds as the denominator.

Table 1
Definitions and examples of peer communication.

Variables	Definitions	Examples
Symbol	Refers to the symbolic representation of a block	"This is a door." "I'm making a door."
Structure design composite		
Design reference	Describes design of the structure, future actions, or building behavior	"I'm going to put more blocks."
Restructuring reference	Refers to restructuring the house due to a problem	"We need to make it so it doesn't fall down."
Quantity composite		
Numbers	Refers to amount or number of blocks or features in the structure	"We need more blocks on this side." "Here's two windows."
Time-related	Refers to the amount of time left in the interaction	"We only have a few minutes left."
Spatial		
Spatial arrangement	Refers to placement or relative spatial arrangement of blocks	"This should be on top." "Move this closer to here."
Size or dimensions	Refers to the dimensions or size of the blocks or the structure	"This one is too small." "We need to make it bigger."

Structure measures

Children's structures were coded at the dyadic level from the pictures. Interrater reliability was established between two raters, one of which was the first author. The second rater was blind to the goals of the current study. Each rater independently coded the structures of 7 dyads (18%), equally distributed over age and gender.

Structural complexity. Structural complexity was created for a larger study on peer cooperation (Ramani, 2012) which was based on four criteria. The first criterion was height and length, which was the number of blocks in the tallest (vertically) and longest part of the structure (horizontally). Numbers were applied separately to a 6-point rating scale: 0 = *no intentional structure*; 1 = 1–2 *blocks*; 2 = 3–4 *blocks*; 3 = 5–6 *blocks*; 4 = 7–8 *blocks*; 5 = 9 *or more blocks*. Scores were summed and could range from 0 to 10.

The second criterion was intricacy, which was the number of different columns (two or more stacked blocks per column) and the number of rows (two or more blocks side-by-side per row). Numbers were applied separately to a 6-point rating scale: 0 = *no columns or rows*; 1 = 1–2 *columns or rows*; 2 = 3–4 *columns or rows*; 3 = 5–6 *columns or rows*; 4 = 7–8 *columns or rows*; 5 = 9 *or more columns or rows*. Scores were summed and could range from 0 to 10.

The third criterion was whether dyads utilized the colors, shapes, or sizes of the blocks in an intentional or meaningful way in their structure (e.g., put all of the large blocks to make the outside of the structure or used the red blocks to make the doors). Dyads did not have to necessarily use multiple colors, sizes, or shapes to receive points for this code (e.g., dyads who only used the blue blocks could have received a score of 2). Scores were based on a 3-point rating scale: 0 = *did not utilize the colors and shapes in a meaningful way in the building*; 1 = *at least one part of the structure utilized the colors or shapes in a meaningful way*; 2 = *at least one part utilized both the colors and shapes in a meaningful way*.

The fourth criterion was number of bridge formations utilized in the building (e.g., two blocks placed parallel to one another with a space between them and another block placed on top over the space). Scores were based on a 3-point rating scale: 0 = *no bridge formations*; 1 = *one bridge formation*; 2 = 2 *or more bridge formations*.

The four scores were summed into one composite to provide an overall measure of complexity for a total score ranging from 0 (did not build anything) to 24. Interrater reliability was calculated for each of the four scores separately with ICCs ranging from .77 to .93.

Structural features. Codes for structural features were adapted from Azmitia (1988). A point was given for the characteristics given by the experimenter that the children included in their structures. This included 1 point for whether the dyads built one structure, and an additional 3 points for whether it included four walls, an entrance, and at least two rooms. Scores ranged from 0 to 4. Each criterion was considered independent of the other criteria. For example, if the dyad built two structures that each had walls, an entrance, and multiple rooms, they received a score of 3 because they built two structures instead of one. Interrater reliability was calculated separately for each of the four criteria with ICCs ranging from .71 to .87.

Data analysis

Because children were building in pairs, a child's talk and behavior could be influenced by the other child in the dyad, which could lead to nonindependence, or a heightened similarity in the children's behavior (Grawitch & Munz, 2004; Kenny, Kashy, & Cook, 2006; Kenny, Mannetti, Pierro, Livi, & Kashy, 2002). ICCs were calculated to test for nonindependence on the talk and building behavior. ICCs were not calculated for the structure measures because they were scored at the dyadic level. Talk and behavior measures between partners were significantly related, which violated assumptions of independence (ICCs ranged .22 to .43). Therefore, measures between the two children were averaged together so the dyad was the unit of analysis. Aggregating across members of each dyad is an analytic technique recommended by Kenny (1996) when partners' behaviors are not independent and the outcome measures are the same for both members of the dyad. Although averaging across the children does not allow for assessing individual children's behavior, it does allow for examining the effects of the dyad as a whole on the structures they built. Others have also used this analytic approach when children's behavior within a dyad is not independent (e.g., Brownell et al., 2006). Because the coordinated action, communication, and building behavior proportions, with the exception of block matching, were not normally distributed, they were transformed using the arcsine transformation for all analyses. This was done in order to ensure normally distributed, linear relations between measures.

Results

The analyses are divided into four sections. First, the descriptive statistics of the children's structures, peer communication, and building behavior are presented. Second, gender differences in the structures the children built, the peer communication, and building measures are reported using *t*-tests and multivariate analyses of variances (MANOVAs). Third, correlations are used to examine the associations between children's talk, building behavior, and structures. Fourth, hierarchical linear regressions are used to examine whether children's coordinated behavior mediated the relations between children's communication, building behavior, and the structures they built.

Descriptive statistics of children's communication, building behavior, and structures

We first describe the time children spent building, the amount and types of peer communication, and the types of building behavior in which children engaged during the guided play activity. As shown in Table 2, dyads spent on average 5.46 out of the 8 min working on the task ($SD = 1.92$; range 1.15 to 8 min). Peer communication and building behavior were coded in 15-second intervals for each interaction, and on average dyads talked during 45% of the intervals out of the total number of intervals during the interaction, although this amount varied with five dyads not talking at all during the interaction and other dyads talking during nearly every interval ($SD = 28\%$; range 0% to 88% of the intervals). Of the 45% of the intervals where dyads talked, children engaged in more talk related to the task ($M = 43\%$ of the total number of intervals during the interaction), compared to talk that was not task-related or was directed to the experimenter ($M = 2\%$ of the total number of intervals), $t(37) = 8.17$, $p < .001$, $d = 2.28$.

We also examined the task-related talk more specifically to better understand the kinds of talk in which children engaged when discussing the task. A greater proportion of the intervals during which task-related talk occurred focused on the symbolic representations and the design features of the house. Dyads also talked about math-related concepts, such as number and spatial relations, although this accounted for a smaller proportion of the task-related talk.

Next we examined children's building and coordinated behavior. Dyads were on-task on average for 98% of the intervals out of the total number of intervals during the interaction with many of the dyads engaged for the entire session ($SD = 5\%$, range = 65% to 100% of the intervals during the interactions). Similar to the peer talk, we were interested in examining the kinds of behaviors in which dyads were engaged. Among the intervals during which building behavior was coded, a large proportion of the intervals involved dyads making block placements that matched the size and orientation of adjacent blocks, as these types of behavior could co-occur with other block placements. During a similar proportion of intervals, children also engaged in block placements involving creating or adding to adjacent rows and columns. In regards to coordinated behavior, dyads spent on average 72.43% ($SD = 37.73\%$, range = 0% to 100%) of the session coordinating their actions with one another, again with great variation in the amount of time children spent coordinating their behavior.

Gender differences in structures, communication, and building behavior

Structure performance

We examined gender differences in the dyads' structures by conducting two independent sample *t*-tests. As shown in Table 2, girls built structures that included more features of a house compared to boys, $M = 2.8$ versus 2.0 elements of the house, $t(36) = 2.03$, $p = .05$, $d = .68$. Although girls also tended to build more complex structures, these differences in complexity scores were not significant, $M = 15.6$ and 14.6.

Communication, building behavior and coordinated action

To examine gender differences in the types of communication children engaged in during the interaction, we conducted a one-way (gender) MANOVA on the four communication variables: Structural design, symbol, spatial, and quantity. Main effects for gender emerged, $F(4, 33) = 2.85$, $p < 0.05$, $\eta_p^2 = .26$. Specifically, boys talked about the structural design of the building during a greater proportion of intervals than girls, $F(1, 36) = 7.28$, $p < 0.01$, $\eta_p^2 = .17$.

We also examined gender differences in children's building behaviors and their coordinated behaviors, conducting an independent samples *t*-test for coordinated action, and a one-way (gender) MANOVA on the four building measures: Vertical placements, horizontal placements, bridges, and block matching. There were no significant gender effects for the building behavior. The independent samples *t*-test also showed there were no gender differences in children's coordinated behavior.

Thus, for the gender comparisons, girls tended to build structures that included more features of a house, whereas boys engaged in communication about the design of the building during a greater proportion of intervals. There were no differences between the boys and girls in the complexity of the structures or their building behaviors.

Relations between structures, communication, behavior, and coordinated action

To determine the relations between the communication, building behaviors, and the structures that dyads built, Pearson correlations were conducted. We first correlated the duration of the interaction with all of the measures to determine whether it should be controlled in any subsequent analyses. As shown in Table 3, the duration was

Table 2
Means and standard deviations for the structure, peer communication, and building behavior measures.

	Overall		Girls		Boys	
	M	*SD*	*M*	*SD*	*M*	*SD*
Interaction duration (min)	5.47	1.92	5.42	1.89	5.51	1.99
Structure measures						
Structural complexity	15.05	4.02	15.56	4.27	14.60	3.83
Structural features	2.39	1.15	2.78	1.17	2.05	1.05
Proportion of intervals with task-related talk [a]	0.43	0.31	0.46	0.29	0.39	0.33
Proportions of intervals with non-task-related talk [a]	0.02	0.07	0.05	0.08	0.01	0.03
Proportions of intervals without talk [a]	0.55	0.27	0.47	0.24	0.54	0.32
Peer communication[b,c]						
Structural design	0.24	0.20	0.15	0.16	0.31	0.20
Symbol	0.30	0.20	0.27	0.22	0.33	0.18
Quantity	0.18	0.15	0.23	0.19	0.15	0.11
Spatial	0.14	0.11	0.13	0.12	0.14	0.09
Building behavior						
Horizontal placements	0.25	0.07	0.25	0.09	0.24	0.07
Vertical placements	0.23	0.02	0.23	0.08	0.24	0.07
Creating bridges	0.02	0.02	0.02	0.02	0.01	0.02
Block matching	0.50	0.07	0.49	0.06	0.51	0.07
Coordinate action (% of total session)	72.43	37.74	72.66	38.67	72.23	37.88

Note. Measures are averaged over the two children in a dyad.
[a] Proportions were out of the total number of intervals for the interaction.
[b] Proportions were calculated for the communication and building behaviors.
[c] Means include dyads who did not talk during the interaction (n = 5), therefore proportions do not equal 1.00.

Table 3
Correlations between structures, peer communication, and building behavior measures.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Interaction duration		.37*	.09	−.20	−.12	.15	.00	−.25	.11	.13	−.22	.11	−.09	.12	.20
Structure															
2. Complexity			.32*	.10	−.20	.07	.24	−.04	−.07	−.07	−.24	.38*	.04	−.14	.37*
3. Features				.10	−.26	−.14	.00	−.13	.11	.39*	.04	−.05	.19	−.07	.57**
4. Task talk					−.07	−.78***	.35	.62***	.29	.34*	.17	−.01	.13	−.18	.22
5. Non-task talk						−.06	.02	.23	.16	.04	.18	−.28	−.29	.21	−.27
6. No talk							−.27	−.47**	−.51**	−.63***	−.28	.23	.05	−.00	−.21
Communication															
7. Design								.26	.07	.28	−.34*	.27	.22	−.21	.19
8. Symbol									.36*	.28	.08	.04	.24	−.21	.02
9. Quantity										.47**	.09	−.04	−.08	−.02	.09
10. Spatial											.14	−.15	.00	.01	.41*
Behavior															
11. Horizontal												−.62**	−.43**	−.24	−.28
12. Vertical													.35*	−.56**	.38*
13. Bridges														−.29	.26
14. Matching															−.20
15. Coordinate action															

*$p < .05$. **$p < .01$. ***$p < .001$.

only correlated with the complexity of children's structures, $r(37) = .37$, $p < .05$. We found the two structure measures, complexity and structural features, were positively correlated, $r(37) = .32$, $p < .05$. Some of the talk measures were also correlated. For example, the proportion of intervals with talk about quantity and spatial were correlated, $r(37) = .47$, $p < .01$. The proportion of intervals with talk about quantity was also correlated with the proportion of intervals with talk about symbols, $r(37) = .36$, $p < .05$. Among the building behavior measures, the proportion of intervals with horizontal placements were negatively correlated with the proportion of intervals with vertical placements, $r(37) = -.62$, $p < .01$, and the creation of bridge structures, $r(37) = -.43$, $p < .01$.

Across the communication and behavior measures, children's talk was not correlated with building behavior. There were no significant relations between the proportion of intervals with building behavior and task-related, non-task-related, or no talk occurring. The one exception was that the proportion of intervals with talk about design was negatively correlated with children's horizontal building behavior, $r(37) = -.34$, $p < .05$.

We also examined how the children's talk related to the two measures of children's structures. The overall amount of task-related and non-task-related talk was not correlated with the children's structures. However, specific aspects of children's talk were correlated with the structural features of a house included in the building, whereas children's building behavior was correlated with the complexity of the structures. Specifically, dyads who engaged in a greater proportion of intervals with spatial talk built structures that included more features of a house, $r(37) = .39$, $p < .05$. Also, dyads who spent a greater proportion of intervals placing blocks in vertical arrangements built more complex structures, $r(37) = .38$, $p < .05$.

Lastly, we examined the correlations between the amount of coordinated behavior and the structures children built. We found that coordinated behavior was correlated with both the complexity, $r(37) = .37$, $p < .05$, and the structural features of the house, $r(37) = .57$, $p < .05$. To further investigate how coordinated behavior was related to the structures that dyads built, we examined whether coordinated action was associated with whether dyads built one structure together during the interaction, which was one component of the structural features measure. We conducted a point-biserial correlation to assess whether dyads received a score for building one structure as a part of the structural features and found that indeed, this score was correlated with children's coordinated action, $r(37) = .73$, $p < .001$.

Coordinated action as a mediator

Another goal of the study was to examine whether the relations between children's talk and building behavior pertaining to the structures that children built were mediated by children's coordinated action. Mediation analyses examine whether a third variable explains the relation between a predictor and an outcome variable (Iacobucci, 2008). This allows us to determine whether children's talk and behavior each directly influence children's building outcomes, or alternatively, whether children's talk and behavior each indirectly influence the structures that children built through children's coordinated behavior. Specifically, we focused on whether coordinated action mediated the relations between spatial talk and the structural features of children's structures,

Table 4
Regression models examining coordinated action as a mediator between children's communication, building behavior, and structure measures.

	Model 1 structural features			Model 2 structural complexity	
Predictors	β	ΔR^2	Predictors	β	ΔR^2
Step 1		.01	Step 1		.14*
Interaction duration	.09		Interaction duration	.37	
Step 2		.14*	Step 2		.27*
Interaction duration	.03		Interaction duration	.33*	
Spatial talk	.33*		Vertical placements	.38*	
Step 3		.20*	Step 3		.03
Interaction duration	−.04		Interaction duration	.29*	
Spatial talk	.19		Vertical placements	.31*	
Coordinated action	.50**		Coordinated action	.19	
Total R^2	.35		Total R^2	.31	
F	6.07**		*F*	5.03**	
F dfs	(2, 34)		*F* dfs	(2, 34)	

*$p < .05$. **$p < .01$.

as well as whether coordinated action mediated the relation between vertical placements and the complexity of children's structures.

As shown in Table 3, we had the necessary relations to test for two mediational analyses (Baron & Kenny, 1986). There are significant relations between: a) the independent variables (spatial talk and vertical placements) and the mediator (coordinated action); b) the independent variables (spatial talk and vertical placements) and dependent variables (structure measures); and as mentioned in the previous section c) the mediator (coordinated action) and dependent variables (structure measures). To establish that a variable mediates a relation, the effect of the independent variables (spatial talk and vertical placements) on the outcomes (structure measures) should no longer be significant upon inclusion of the mediator (coordinated action).

Table 4 shows the regression models testing the role of coordinated behavior as a mediator between dyads' spatial talk and the features of a house they included in their structures. Because the duration of the interaction was correlated with the complexity of the structures, it was included as a control variable in the first step of the regressions. We found that the relation between spatial talk and structural features was no longer significant when coordinated action was included in the model, and coordinated action was a significant predictor of structural features, $\beta = .50$, $R^2 = .35$, $F(2, 34) = 6.07$, $p < .01$, explaining an additional 20% of the variance. A bias-corrected bootstrapping procedure (Preacher & Hayes, 2004) gave a 95% confidence interval of .16 to .83, which does not contain zero. This suggests that the reduction in the direct relation between spatial talk and dyad's structural features was significant, and that coordinated action mediated this relation. Thus, spatial talk influences the features that dyads included in their structures through an increase in coordinated action between the partners.

In a second regression (Table 4), we examined whether coordinated action mediated the relation between children's building behavior, (i.e., vertical placements) and the complexity of their structures. Unlike the relation between spatial talk and structural features of the house, coordinated action did not serve as a mediator in this model. Children's vertical placement of blocks was still a significant predictor of the complexity of the structures after adding coordinated action to the model. Overall, coordinated behavior mediated the relation between spatial talk and the structural features that dyads included in their buildings, but coordinated action did not mediate the relation between children's building behavior and the structural complexity of the buildings.

Discussion

The goal of this study was to examine preschool-aged children's peer communication and building behaviors during a guided block building activity with a same-age, same-sex peer. Specifically, we were interested in examining the processes involved in preschoolers' construction of a house, including their individual block placements, and how they communicated and coordinated their efforts throughout the interaction with their building partner. We also examined whether gender differences existed in children's building behaviors and their building-related communication. Additional associations were explored between children's building and coordinated behaviors, the complexity of the final structures they built, and the features of a house included in their structures. In this section, we discuss our findings in terms of these goals, and then consider their educational implications.

Preschool children's joint block building and peer communication

One goal of the study was to examine preschool children's talk and block building behavior. Although previous research has typically focused on the outcomes of children's building, we observed children *during* a guided play activity with a peer, and found that they engaged in a variety of building behaviors and discussion during the interaction. Overall, children varied widely in the amount of time they spent on the interaction, as well as how much they communicated with one another. Some of the dyads spent nearly every interval communicating, whereas other dyads did not talk at all. When children were talking, they mainly discussed the task, and did not talk with the experimenter or about non-task-related topics, suggesting that dyads were very engaged in the guided play activity. Interestingly, children's total task-related talk, non-task talk, and even lack of talking during the interaction were not related to their building complexity or the features of the house included in the structures. This suggests that the quality, and not necessarily the quantity, of children's communication is associated with the structures they built. Of the task-related talk, we found that children mainly discussed the symbolic representations of the blocks and design of the structures. This type of talk is consistent with previous research examining peer communication during block play (Reifel & Yeatman, 1991). When children discuss the symbolic representations of blocks, they are attempting to create a shared understanding with a peer, which is believed to be the type of discourse that can help build language skills among young children (Cohen & Uhry, 2007).

Further, we found that children also engaged in spatial and quantity-related talk during the interaction, although during a smaller proportion of the intervals. For example, children talked with their partner about the number of features or blocks in the structures, and spatial relations between the blocks. The type of talk may be particularly important for understanding the benefits of block play for children. For example, Pruden et al. (2011) have found that children who produce more spatial language between the ages of 14 to 46 months perform better on spatial problem-solving tasks at 54 month. This suggests playing with blocks with peers may help children to build their spatial understanding and numerical understanding through the spatial and quantity-related talk that takes place during the interaction.

Children also engaged in a variety of building behaviors during the interaction. For example, children made horizontal and vertical block placements to make towers and rows in their houses. Similar to children's talk, these building behaviors can have numerous benefits for children. Many have theorized that stacking and placing individual blocks can develop children's abilities in measurement, symmetry, estimation, part–whole relationships, and spatial relations (Casey & Bobb, 2003; Kamii et al., 2004; Ness & Farenga, 2007). We also observed that many of the block placements children made matched the size and orientation of previously placed blocks. This further demonstrates how block building could help promote children's geometric and spatial reasoning skills. Overall, our observations of children's behavior during joint block play suggest that this play context provides opportunities for children to practice and develop linguistic skills, as well as build and apply foundational spatial and math skills.

Peer interactions during block play

Another goal was to examine how children's peer communication, building behaviors, and coordinated action *during* the interaction related to the quality of the final structures they built. Overall, we found a large range in the amount of time children spent coordinating their behavior with a peer. This variation was associated with the complexity of children's structures and the features of a house that dyads included in their building, such as whether dyads built one structure together. Further, we found that coordinated action mediated the relation between children's spatial talk and the number of features of a house included in their structures. This suggests that the mechanism through which spatial talk influences the structures that children built is the amount of coordinated peer interaction it encourages. Others have observed that preschool-age peers discuss building ideas and symbolic meanings of blocks during block play (Reifel & Yeatman, 1991). Our results further suggest that in order to build symbolic features of a house, children communicated specifically about the spatial relations between the blocks. This kind of talk encouraged partners to coordinate their behavior to complete these common goals by constructing different components of the house or working together to build a specific feature of the house. Thus, building one structure and including structural features of a house was accomplished by children working together to complete these common goals.

We also examined how children's building behavior was related to the complexity of the structures they built. We found that children's vertical block building was associated with the complexity of their structures. Children's coordinated action, however, did not mediate these relations. This suggests that children's individual building behaviors were directly associated with the structures that children built. It is possible that children's building behaviors may not influence coordinated behavior the way communication between peers would. For example, children could individually contribute to the complexity of a structure by placing blocks to make towers without necessarily coordinating their behavior while doing so.

Even though coordinated action did not serve as a mediator in both regression models, it did correlate with both of measures of children's structures. It is likely that when children work together they can both add to the complexity of the structure, perhaps by both children working on one section of the building together or by one child providing ideas about the design and the other following through with the suggestion. This coordinated action was also highly related to whether dyads built one structure together, which demonstrates that working with a peer plays an important role in the buildings that they create. Previous research on block play has focused on children's individual building behavior; therefore, little is known about the nature of joint block building. Research on cooperation during structured problem-solving tasks where partners work together to receive rewards has shown that toddlers and preschoolers are sophisticated at working with a partner to complete joint goals, asking partners for assistance, and coordinating their behavior (Ashley & Tomasello, 1998; Brownell et al., 2006; Hamann et al., 2012). Similarly, during block play, children must establish a joint goal and use strategies to solve problems that arise to meet their joint goal (Ramani & Brownell, 2014). Thus, our results suggest that building with blocks provides an alternative naturalistic play context where children must coordinate their actions and utilize sophisticated behaviors for successful peer interactions.

Gender differences in children's block building structures

An additional goal of the study was to examine gender differences in children's block building to better understand how a guided play activity influenced both the building complexity and the symbolic features children included in their structures. We found that girls built structures that included more symbolic features of a house, such as a door and rooms; however, we did not find any gender differences in our measure of structural complexity. These results are consistent with previous research that has found building complexity does not differ between boys and girls during guided play activities (Reifel & Greenfield, 1982). Typically, block building research focuses on the complexity of children's final structures (Kersh et al., 2008) rather than what those structures represent symbolically. By including a measure of the structural features of the house as well as structural complexity, we found that girls built structures that more resemble the goal of the task.

Our results suggest the importance of examining measures of both the symbolic features and complexity of children's structures. Complexity is not consistently defined in the literature and is measured using various approaches (Kersh et al., 2008). Having a consistent measure would allow for a better understanding of how block building develops over the toddler and preschool years, how it may differ between boys and girls, and how it varies across contexts and activity type. Furthermore, consistently measuring both complexity and the symbolic features or representations of the house could provide insight into different types of knowledge that children could gain from playing with blocks. For example, our coding system captured several symbolic representations that experimenters included in the instructions. Future research could also examine additional features of the house, such as the chimney or garage, which would further capture children's symbolic representations in their structures. Overall, given that building with blocks can have an imaginative, playful component, as well as a skilled spatial component, taking multiple measures of the structure into account is likely important when assessing children's structures and building abilities of both boys and girls.

Importance of guided play and joint block play activities in early childhood education

The results of the study have important implications for early childhood classrooms and avenues for future research. One implication is the importance of using guided play activities, especially in block areas, to engage both boys and girls. Understanding gender differences in block building is of wide interest, because some gender differences have been found in children's performance on math and spatial tasks. For example, high school boys have an advantage over same-age girls on mathematics problems that require applying knowledge to new contexts (Hyde, Fennema, & Lamon, 1990). Promoting block play during the preschool years may help eliminate or reduce these gender differences. For example, a longitudinal study conducted by Hanline, Milton, and Phelps (2001) observed young children's block play over three years, providing equal amounts of time for all children to play in the block area. Their observations did not reveal any gender difference in the complexity of children's structures, which suggests that equal experiences in the block area may benefit block building skills in boys and girls.

We also did not find any differences between boys and girls in their coordinated behavior, building behavior, or building complexity. This suggests that both boys and girls were similarly engaged in the joint guided play building activity. Although block play is often a free play activity in early childhood classrooms, incorporating guided play activities may be an enjoyable and motivating way for both boys and girls to learn, practice, and develop important skills (Hirsh-Pasek et al., 2009). For example, guided play activities with peers could increase the problem-solving skills children use when building more than unstructured block play (Kersh et al., 2008), as well as cooperative and linguistic skills. Future research on guided play activities can provide insight into how these activities may elicit interest in the block area and how this may benefit both boys and girls in early childhood classrooms.

A related implication is the importance of utilizing guided play activities with peers to promote early math and spatial abilities in young children. We observed that dyads engaged in talk about math-related concepts, such as number and spatial relations, as well as matching the size and orientations of blocks when building. This suggests that working towards completing the goal of the guided play activity may elicit talk about the size and relations between blocks, which could strengthen children's spatial understanding. For example, parents and children engage in more spatial talk during a guided block play activity than during free play with the blocks, which suggests that guided block play activities could be valuable in promoting the use of spatial language (Ferrarra, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011). Furthermore, guided play is more beneficial than free play and didactic instruction on improving preschool children's knowledge of shapes (Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013). Talking about numbers with peers, exploring math-related concepts during play, and engaging in informal learning activities about numbers can be valuable ways for children to expand their existing skills and gain new knowledge (Ginsburg, Lee, & Boyd, 2008; Ramani, Siegler, & Hitti, 2012; Seo & Ginsburg, 2004). Recent work has shown that 3-year-olds' spatial skills are related to their concurrent mathematical performance (Verdine et al., 2013), which demonstrates the importance of early spatial abilities for mathematical achievement Even though there is some evidence that construction with blocks contributes to foundational knowledge in math and reading (Hanline, Milton, & Phelps, 2010; Wolfgang et al., 2001), greater longitudinal research is needed to understand the long-term benefits of guided play activities and playing with blocks on children's math and spatial abilities.

Limitations and conclusions

A few limitations of the study should be noted. First, the sample used in the study was fairly small and homogeneous. All of the children attended child-care centers that promoted block play and joint play among classmates. Future research should examine joint block building with a more diverse sample and in child-care centers where less emphasis is placed on joint activities and more emphasis is placed on individual activities. Another limitation is that children's behaviors could have been influenced by the camera that was used to videotape the interactions. However, the time that children spent off-task and speaking with the experimenter was very limited, which suggests that the children were not reacting to the camera during the interaction. Finally, some of the proportions of the talk during the interaction, such as spatial talk, were relatively low. Despite these low proportions, this type of talk was associated with children's coordinated behavior and their structures. It is likely that the overall quantity of specific kinds of talk may not be as important as the quality of the talk. Future work needs to continue to examine children's talk in-depth during block play. This could include examining patterns of children's talk during block building to examine how talk may vary during the initial and later stages of a building interaction. This detailed coding may be necessary to understand exactly how language can contributes to children's concurrent and later abilities.

In sum, joint block building allows children to use and practice their language, spatial, math, and joint problem-solving skills. The current findings demonstrate the importance of examining children's peer communication, building behavior, and coordinated action during block play to understand how they are associated with the symbolic features as well as the complexity of children's structures. Our results suggest that joint guided play activities could be used in the block areas of early childhood classrooms to elicit important talk between peers and skillful behavior when children are completing the joint goals of the building activity.

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