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Peer interactions during storybook reading on children's knowledge construction: an experimental study on K2 and K3 children

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This study explored the effects of peer interactions on kindergarten children's construction of conservation and conflict resolution knowledge during storybook reading. Previous studies have identified that peer interactions can support the meaning-making processes of children in social relationships and problem-solving, but little is known about whether the interaction with mixed-age or more competent peers is more important in supporting knowledge construction. Sixty-four younger children in K2 and older children in K3 with similar socioeconomic backgrounds were recruited from a Montessori kindergarten in Kunming, China. An experimental design was applied to explore age group and conserver dominance effects on conservation and conflict resolution. Children were assigned randomly to eight groups in three 30-to-40-min intervention sessions. Each session had a different theme for the children to learn about conservation and conflict resolution concepts and a hands-on activity to practice and discuss. ANOVAs were performed to test group effects, while multiple regression analyses were conducted to explore individual variations in age and pre-test scores in predicting post-test scores. Conservation knowledge was significantly better among children who differed in age groups in the post-test, but differences were not found in conflict resolution knowledge. Groups balanced with equal conservers and non-conservers improved the best, suggesting that peer social interactions can facilitate conservation and conflict resolution construction. These results provide new insights for early childhood educators to support peer interactions and children's development. Implications, limitations, and future research are discussed.

KEYWORDS

dialogic teaching, conservation, knowledge construction, reading, social knowledge

Introduction

Peer interactions promote children's learning outcomes

Children may be in an equal position when interacting with peers, which they do not experience in adult-child interactions because the shared control and responsibility engage their active participation and decision-making autonomy (Garrett, 2008). To maintain interpersonal relationships, children learn to regulate their own behaviors, develop social skills, resolve conflicts, and consider peers' perspectives (Lin et al., 2016). In addition, the interactions among peers provide opportunities to communicate, construct, and imagine, which leads to the further development of cognitive skills (Semmar and Al-Thani, 2015). The verbal and non-verbal assistance and the modeling during peer interactions contribute to children's cognitive, social, and communicative development (Riad et al., 2023). The quality of social interactions with peers enhances their learning (Sills et al., 2016) and encourages their motivation, engagement, and interest in school (Sjöman, 2023). They serve as an integral part of cooperative and collaborative learning opportunities in the classroom (Akçayır and Akçayır, 2018) and support children's learning behaviors, including positive attitudes toward learning, persistence on tasks, and motivation for long-term learning (Suárez-Orozco et al., 2018).

Furthermore, it has been found that children who participate in more interpersonal interactions with peers are better at analyzing discourse and learning tasks (Gerber et al., 2008). The development of higher-order thinking is generally associated with synergistic interaction patterns, in which children form groups with their peers and produce explicit or implicit responses to each other's thoughts and ideas (Schrire, 2006). Peer collaboration to reach a common approach to solving problems together can help children achieve high-quality group work, eventually resulting in individual development and success (Kreijns et al., 2022). Peer interactions establish versatile contexts for children to receive modified input, notice expressive misunderstandings, produce output, negotiate meanings, and give and obtain interactive feedback (Gass and Mackey, 2006; Mackey, 2013). Peer interactions and cooperation positively predict children's learning outcomes, independence, and psychological attributes such as confidence and self-efficacy (Johnson and Johnson, 2009).

Interactions with more competent peers help children construct knowledge

Brillante (2023) complemented the above information with evidence that interactions with more competent peers positively influence young children's development, helping them build social, cognitive, and language skills to establish effective relationships. Parker et al. (2022) emphasized that positive and cooperative interactions with more competent peers enable children to obtain social knowledge and skills and engage them in experiences promoting early literacy and mathematics development. In this way, it has been argued that since social competence is a significant indicator of young children's school readiness, childcare practitioners are responsible for scaffolding social area learning in early childhood (Blair and Raver, 2015). Studies (Nicolopoulou et al., 2006, 2015) report that peer interactions occur naturally within preschool classrooms, and more knowledgeable peers can support and model children's early skills in the cognitive domain. Further evidence suggests that positive peer interactions with high-ability children can improve low-ability children's developmental skills, including self-regulation, cognitive flexibility, perspective-taking, and problem-solving strategies, which significantly support children's learning during classroom instruction (Coplan and Arbeau, 2009).

Mixed-age peer interactions in Montessori classrooms

Compared to the principles and practices of conventional schooling, Montessori education has shown more optimal results in children's development (Lillard, 2017). Children can constructively choose their activities, discover personal interests, and work with peers in a multi-age collaborative environment structured by various materials (Lillard et al., 2017). One of the most significant designs of the Montessori context is the children's interaction with the environment, materials, and community, and such interaction facilitates self-control and mastery (Phillips-Silver and Daza, 2018). Children can refer to their behaviors and predictions when receiving instant sensory feedback from the context, including the classroom design, learning materials, and relationships with the teacher and other students (Montessori and Johnstone, 1948, 1962). In this way, in mixed-age classrooms, younger children can observe and model older children on how they behave and how they use the materials, and the act of mentoring and learning can occur naturally even when younger children have not mastered it yet (Montessori, 1965). The collaborative work and cooperative relationships among children of different ages create opportunities to reflect on their actions, make self-corrections, and obtain mastery independently of the adult (Montessori and Claremont, 1984).

The types of knowledge children construct

Conservation as the prerequisite of physical and logical-mathematic knowledge

According to Piaget (1970), children first realize an object has a certain permanency, and it does not change because of its position—such physical knowledge is one of the foundations and starting points for the notion of conservation. Later, when children grow older, the operation of compensation and reversibility development promotes changes in their logical and mathematical thinking, and finally, the ability to conserve is built up (Piaget, 1970). Conservation consists of the "discovery" of things that already exist in external reality and continuous "construction"; therefore, conservation is an example of the child's logico-mathematization of physical knowledge (Kamii et al., 2004).

Conflict resolution as social knowledge

A conflict arises "when one person does something to which a second person objects" (Hay, 1984). Children in different age groups have different levels of conflict management skills (Harold and Sellers, 2018). Still, younger children are less competent in understanding others' perspectives and feelings (Laursen and Adams, 2018), identifying others' intentions, and applying helpful conflict resolutions (Spivak, 2016). The lack of the ability to resolve conflicts may hinder peaceful resolutions and can sometimes lead to dominating and even violent behaviors (Stone and Heen, 2014).

Conflict is an essential precursor to the development of children's cognition and logical abilities (Traverso et al., 2015). Many studies have investigated strategies for interpersonal conflicts and peaceful resolutions (Shen et al., 2018; Klimecki, 2019). Conflicts among young children are often regarded as isolated individual behaviors (Doppler-Bourassa et al., 2008), but (Hayes et al., 2017) considered they are more likely the by-products of social contexts.

Literature review

Peer interactions support children's cognitive development

As stated by Piaget (1971), human beings can extend biological programming to build up the systems of cognitive development that interpret other people's experiences. When children construct cognitive systems, they can understand other children in the mutual context of their actions and performances, and the objective experience can be comprehended and interpreted. Therefore, in a given classroom environment, a child's meaning-making processes can be fundamentally different when the child works with other children rather than alone (Piaget, 1978).

Peer interactions offer children rich and necessary contexts in which they can modify the cognitive systems they build, and the reflections of perspectives, feedback, and reactions from their peers perform as a principal base for children to make revisions and, in turn, make new meanings (O'Donnell and King, 2014). When an older and more capable individual serves as a model, a child's cognitive development of reasoning and problem-solving of specific tasks is apparent (Renninger et al., 2014). Children's conceptual changes are more likely to occur when there are more competent peers in a group where children can interact and collaborate (Piaget, 1985).

On the other hand, the Vygotskian perspective sees the development of human beings as a socio-genetic process through which children can become mature by utilizing cultural tools and signs during their interactions with others in their environments. These "others" are often more competent individuals who can assist children to comprehend certain concepts and use appropriate significant tools and signs within specific cultural groups or contexts (Parker et al., 2015). The interaction between the child and more competent peers are considered to be most effective for the child's development when the interaction occurs within the child's zone of proximal development (ZPD) (Vygotsky and Luria, 1994). When there are more competent individuals in the group, children are more likely to achieve an early growth in cognitive and psychological aspects through two-way interactions (Vygotsky and Luria, 1993).

It has been argued that a mixed-age classroom allows for progression at children's individual speed, addressing their needs and interests, thereby enhancing their learning behavior and reducing age-related prejudices (Gray, 2011). When interacting with mixed-age peers, children stimulate each other's knowledge, abilities, and perspectives, improving student-centered education and children's higher-order thinking skills (ErtÜRk-Kara, 2018). Children can model positive behaviors and resolve more cognitively challenging material and activities in a mixed-age classroom environment (Justice et al., 2019). With the support of mixed-age groupings, children have been found to participate in more complex play, ask more questions, engage in problem-solving, and exhibit a more sophisticated use of language (Rouse, 2015).

> *H1: Children in the mixed-age groups and groups with more competent peers construct conservation better (See **Figure 1**).*

Peer interactions support children's social development

Peer interactions and relationships give children equality, which is hard to achieve in adult-child communications. They establish the mental foundation for children's perspective-taking and decentralization because they are more likely to act and think autonomously with other peers (Piaget et al., 1995). Piaget saw social factors as having a central role in children's construction of knowledge, and social life creates a necessary condition for the development of logic and strategies. The interactions among individuals enable them to modify each other's psychological structures and make individuals adapt to social operations in different social contexts (Piaget, 1928). The peer interactions help establish the classroom community, where children can discuss social and moral issues, promote conflict resolution, and interact with what they learn (Stetsenko, 2017). In a group with more competent peers, children are offered an approach to others' perspectives, to make reflections and coordinate their perspectives, and to assist in solving the contradictions between others' perspectives (Tenenbaum et al., 2020).

Similarly, Vygotsky's sociocultural theory explained the role of dialogs among peers in structuring the origin of children's social-cognitive functions and shaping children's recognition of social practice (Topçiu and Johana, 2015). According to the Vygotskian view, the sociocultural environment offers children opportunities to confront a diversity of ideas and questions, initiate their decisions and thoughts, and receive social knowledge through interactions (Crain, 2015). During these interactions, children are not simply imitating their peers but transferring what they are learning from the dialogs into personal values they can apply on a daily basis (Marginson and Dang, 2017). The concept of "social" in the sociocultural perspective is not simply an individual's environment or a particular action but the reflection of activities conducted by the people in the same context (Vygotsky, 1987). When children have more chances to interact with competent peers in a group, a progressive social and cultural community where

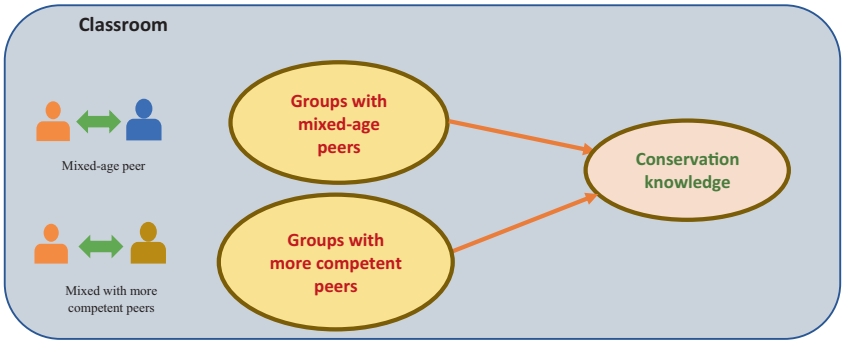

FIGURE 1
Peer interaction on children's development of conservation knowledge.

children's actions and behaviors are structured and defined is more likely to be established The peers play a relational and negotiable role during the interactions and lead children to form a progressive social and cultural community in which their actions and behaviors are structured and defined (Matusov and Hayes, 2000).

It has been demonstrated that mixed-age grouped classrooms were highly significant in predicting the increase of children's prosocial and friendship behaviors and the decrease of negative and aggressive behaviors (ErtÜRk-Kara, 2018). The mixed-age environment allows the exhibition of the diversity of different age groups, leading to socio-cognitive conflicts that stimulate children's eagerness to learn and develop positive attitudes to reach a consensus (Smit and Engeli, 2015). It has been found that there are fewer dominant behaviors (such as biting, hitting, etc.) in mixed-age groups (Logue, 2006), where older children have the opportunity to be helpful, patient, and tolerant, and younger children are exposed to models of behavior (Rouse, 2015). Children in mixed-age groups are more likely to establish more reciprocal relationships and deeper social interactions with peers than those in same-age groups (Wu et al., 2022).

> *H2: Children in the mixed-age groups and groups with more competent peers construct conflict resolution better (See **Figure 2**).*

Research objectives and questions

This study investigated the effects of peer interactions during storybook reading on young children's knowledge construction in Kunming Montessori kindergartens. The objective of the current study was to provide empirical evidence about whether children in mixed-age groups and groups with more competent peers can construct conservation and conflict resolution better.

It has been demonstrated that children in the mixed-aged groups developed a higher level of cognitive functioning and socio-emotional competence than children in the conventional groups (Ervin et al., 2010; Kayılı, 2018), but there is limited and dated empirical evidence about whether children in mixed-age groups can construct conservation and conflict resolution better than children in conventional groups. In addition, while previous studies (Mackey, 2013; Akçay, 2016) identified that children can acquire cognitive, social, and communicative development from competent peers, the learning outcomes of whether children in groups with more competent peers can construct conservation and conflict resolution better than children in groups with less capable peers have not been studied yet.

The Research Questions (RQ) investigated in this comparative examination were:

> RQ1: Do children in mixed-age groups construct conservation and conflict resolution better than other groups?

> RQ2: Do children in groups with more competent peers perform better in constructing conservation and conflict resolution than other groups?

Materials and methods

Research design

The current study applied the experimental design to collect numerical data and explain a specific phenomenon (Campbell et al., 2015). A pre-test and post-test design was adopted to compare and measure changes during and after the experimental treatments (Alam, 2019). The study investigated two conditions: the *age group* (same age but younger, K2; same age but older, K3; and mixed age, K2 + K3) and the *conserver dominance* (non-conserver dominant, ND and balanced, BL) and their effects on children's construction of conservation knowledge and conflict resolution knowledge. This grouping design was a compromise because the research was conducted during COVID-19, which limited the time and access to finding more participants to allow for studying the grouping effects in separate experiments.

Participants

The data collection was conducted in Kunming, Yunnan Province, China. Kunming is the capital city of Yunnan Province in

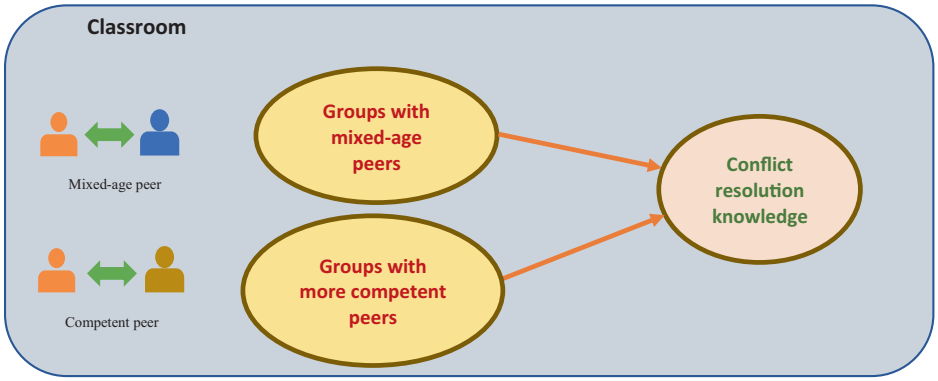

FIGURE 2
Peer interaction on children's development of conflict resolution knowledge.

southwest China. According to the Kunming Statistical Yearbook (Zhong, 2019), there were 1,329 kindergartens in Kunming by the end of 2019. Founded in 1953, Kindergarten Y is a government-run public school with 28 classes and approximately 1,000 children. Kindergarten Y applies Montessori education to establish a learning environment mixing academic learning, play, and natural contexts for child development (Lan, 2009).

There were 64 participants in total: 32 K3 children and 32 K2 children from 6 randomly selected classes. An *a priori* power analysis was conducted using G*Power (Faul et al., 2007) for sample size estimation to achieve 80% power at a significance criterion of $\alpha = 0.05$. The results indicated the required sample size to achieve 80% power for detecting a medium effect at a significance criterion of $\alpha = 0.05$ was $N = 24$. Thus, the obtained sample size of $N = 64$ was more than adequate to test the hypothesis. There were 25 female participants and 39 males. As described above, the K3 children were aged 6–6.5 years, and the K2 children were aged 4.5–5 years. They were randomly divided into eight groups of 8 based on their pre-test scores of conservation knowledge. Children earning 30 points or above on conservation tasks were considered conservers. Otherwise, they were classified as non-conservers. There were eight groups: one non-conserver dominant K2 group, one non-conserver dominant K3 group, two balanced K2 + K3 groups, two balanced K2 groups, and two balanced K3 groups (see **Table 1** and **Figure 3**).

The significant differences among the eight groups were age group (K2, K3, K2 + K3) and conserver dominance (non-conserver dominant, balanced). In the K2 and K3 groups, all peers were from the same respective grade levels, while in the K2 + K3 groups, there were 4 K2 children and 4 K3 children. In the non-conserver dominant groups, there were two conservers and six non-conservers. In the balanced groups, there were four conservers and four non-conservers. The researcher read the story to the children and put forward questions for them to discuss with peers without the researcher's involvement.

Procedure

Pre- and post-test

After collecting all the consent forms from the kindergarten principal, teachers, and parents, the researcher sent the hard copies of the demographic questionnaires to the teachers, and the teachers helped distribute them to the participating parents. Then, the researcher went to the kindergarten to collect the finished questionnaires in person. Subsequently, the researcher started to invite children to participate in the pre-test. The pre-test was conducted in a quiet room in the kindergarten to ensure the participants were familiar with the environment. Only one participant was brought to this room to minimize distractions during the data collection. After the pre-test, the researcher sent each child back to the classroom. The data collection sessions took place during school hours. The researcher's instructions and the responses from the participants were conducted in Mandarin. The procedure for the post-test was the same as for the pre-test.

Intervention sessions

After the pre-test, the children were allocated to groups of 8 based on their performance on conservation tasks. The children stayed in the same groups for the whole intervention. Each group was invited to participate in three intervention sessions conducted by the researcher, each lasting for 30–40 min. Each session had a different theme for the children to learn about conservation and conflict resolution concepts and a hands-on activity to practice and discuss. The researcher recorded each teaching session to note the narratives and dialogs for analysis. The intervention sessions were conducted in a quiet room in the kindergarten to ensure the participants were familiar with the environment. Only one group of participants was brought to this room at a time to minimize distractions during the data collection. The researcher sent each group back to the classroom after the session. The data collection sessions took place during school hours. The language medium was Mandarin, including the researcher's instructions and the responses from the participants.

Instruments

Conservation tasks

The conservation tasks were adapted from the *Conservation Scales* (Goldschmid, 1967; Goldschmid and Bentler, 1968). Goldschmid and Bentler (1968) identified ten areas of conservation tasks demonstrated by other researchers (Piaget, 1951;

TABLE 1 Grouping of children (n = 64).

Group	Conserver dominance non-conserver dominant (ND) vs. Balanced (BL)	Age group K2 vs. K3 vs. K2 + K3	Age
1	ND	K3	6.09
2	ND	K2	5.01
3	BL	K3 and K2	5.49
4	BL	K3 and K2	5.69
5	BL	K3	6.11
6	BL	K3	6.06
7	BL	K2	5.00
8	BL	K2	5.00

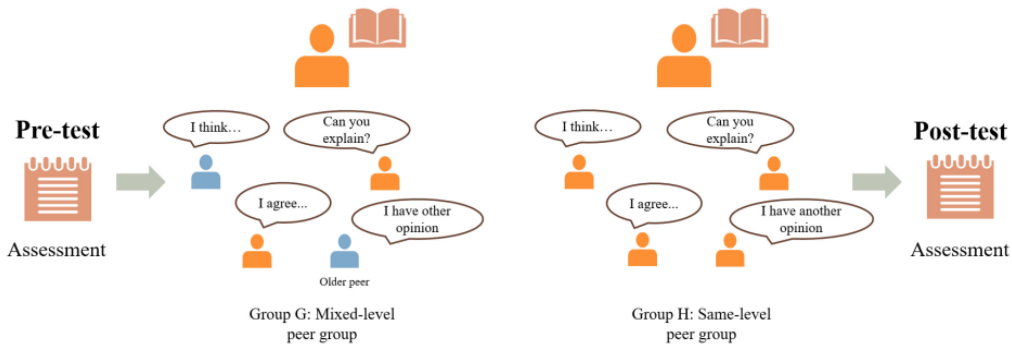

FIGURE 3
Goals and design of the study.

Elkind, 1967). This instrument is well-established, with sound statistical properties. It has a high consistency and statistical accuracy level for evaluating children's conservation knowledge with several tasks and has been adapted by previous studies (Perret-Clermont, 1980; Weisz and Yeates, 1981). Scale A was administered to all children with six tasks (i.e., two-dimensional space task, number task, weight task, substance task, continuous quantity task, and discontinuous quantity task). In comparison, Scale C, with two more challenging conservation tasks (i.e., area task and length task), was administered optionally for children who succeeded in all tasks in Scale A. Each assessment lasted for about 10 min.

Conflict resolution tasks

The conflict resolution tasks were adapted from Reunamo (2004). Their social orientation and the strategies they used to resolve the social conflicts with peers were considered as an indicator of their underlying knowledge about conflict resolution (Hopmeyer and Asher, 1997). The participating children were asked six situational questions individually to measure their strategy use in social interactions, and the researchers categorized their answers into four dimensions. Each assessment lasted for about 5 min.

The storybook

A Chinese reader, *The Twin Brothers—Conservation of Physical Quantities*《雙胞胎兄弟：量 的守恒》(Liu, 1991) was selected for three reasons. First, it introduces the concept of conservation to children through everyday situations. Children are expected to learn that changing the shape/container does not change the volume of a solid/liquid substance, and it was expected that their understanding of the measurement concept and tools would be deepened after the study. Second, the story tells children how to resolve life/social situational conflicts. In the story, the twin brothers always fight with each other because they do not understand the concept of conservation. However, they still love and help each other, especially in dangerous situations. Children are expected to learn how to realize their roles in social situations, sensitively evaluate the environment, and take the initiative to change (Reunamo and Hällström, 2013).

Instrument reliability

The following two constructs were measured: children's conservation and conflict resolution knowledge. Construct reliability (internal consistencies) was assessed by the composite reliability (Cronbach's α analysis) (see **Table 2**).

The reliability analyses displayed that the Cronbach's Alpha values for the two instruments were valid, which means that the instruments all had high levels of internal consistency.

Data analysis strategies

To address RQ 1 on the effect of mixing with peers of the same ages or different ages, the three-way mixed ANOVA (Okereke et al., 2020) was conducted to examine differences

TABLE 2 Reliability analysis of the instruments.

Factor	No. of items	Cronbach's α	Range of item-total correlations
Conservation knowledge (CONS)	24	0.974	0.643–0.863
Conflict resolution knowledge (CR)	12	0.752	0.330–0.477

between K2 (same age younger), K3 (same age older) and K2 + K3 (mixed ages) groups in terms of how they constructed conservation and conflict resolution.

To address RQ 2 on the effect of mixing with peers with higher abilities, the three-way mixed ANOVA (Okereke et al., 2020) was conducted to examine differences between NC groups (non-conserver dominant) and BL groups (balanced) in terms of how they constructed conservation and conflict resolution.

The standard multiple regressions (Osborne, 2019) were also applied to explore the prediction of children's age and pre-test scores on their post-test scores.

Findings

Conservation knowledge

Descriptive statistics

Descriptive statistics for the conservation pre-test scores revealed differences in the five groups, that is, the non-conserver dominant K2 group (n = 8), the balanced K2 groups (n = 16), the non-conserver dominant K3 group (n = 8), the balanced K3 groups (n = 16), and the balanced K2 + K3 groups (n = 16). It showed that the mean pre-test score for the conservation tasks in the non-conserver dominant K2 group was 14.13 (SD = 3.94); in the balanced K2 groups it was 20.31 (SD = 12.00), in the non-conserver dominant K3 group it was 22.75 (SD = 21.08), in the balanced K3 groups it was 38.19 (SD = 22.75), and in the balanced K2 + K3 groups, it was 37.25 (SD = 24.49).

Descriptive statistics for the conservation post-test scores revealed the five groups' differences. It showed that the mean score for the children's post-test scores on the conservation tasks in the non-conserver dominant K2 group was 13.88 (SD = 3.18). In the balanced K2 groups, it was 24.88 (SD = 16.30); in the non-conserver dominant K3 group, it was 25.75 (SD = 21.39); in the balanced K3 groups, it was 51.88 (SD = 20.47); and in the balanced K2 + K3 groups, it was 45.00 (SD = 26.93).

Overall, children's conservation task performances improved significantly [t (119) = −4.19, $p < 0.01$], and the effect sizes were medium for all groups (d = −0.52).

The descriptive statistics above indicated that the children in the balanced K3 groups made the most significant progress in constructing the conservation knowledge from pre-test to post-test, followed by those in the balanced K2 + K3 groups. In addition, the children in the balanced K2 groups also made some progress in comprehending conservation knowledge. The scores of the children in the non-conserver dominant K2 group and non-conserver dominant K3 group in the pre-test and post-test did not appear to have distinct differences (see Table 3).

Three-way mixed ANOVA

A three-way mixed ANOVA was run to understand the effects of age group, conserver dominance, and time on the children's construction of conservation knowledge. The three-way interaction between time, age group and conserver dominance was not statistically significant while controlling for gender and class, [$F_{(1,53)}$ = 0.702, p = 0.406]. There was no time effect based on age group for children in the same group [$F_{(2,53)}$ = 0.900, p = 0.413].

Still, there was a statistically significant two-way interaction between time and conserver dominance for children in the same group [$F_{(1,53)}$ = 4.096, $p < 0.05$, $\eta^2 p$ = 0.072]. There was no additional two-way interaction between age group and conserver dominance, [$F_{(1,53)}$ = 1.231, p = 0.272]. The statistical significance of a simple main effect was accepted at a Bonferroni's-adjusted alpha level of 0.025.

There was a statistically significant simple main effect of age group at the post-test level, [$F_{(2,53)}$ = 8.174, p = 0.001, $\eta^2 p$ = 0.236, and at the pre-test level, $F_{(2,53)}$ = 5.264, p = 0.008]. There was a statistically significant simple main effect of conserver dominance at the post-test level, [$F_{(1,53)}$ = 10.155, p = 0.002, $\eta^2 p$ = 0.161, but not at the pre-test level, $F_{(1,53)}$ = 4.044, p = 0.049]. All pairwise comparisons were performed for statistically significant simple main effects. Bonferroni's corrections were made with comparisons within each simple main effect considered a family of comparisons. Adjusted p-values are reported here. The mean post-test score was significantly higher in the K3 group than in the K2 group, with a mean difference of 20.192, 95% CI [3.603, 36.781], p = 0.012. The mean post-test score was significantly higher in the K2 + K3 groups than in the K2 groups, with a mean difference of 26.867, 95% CI [9.370, 44.365], p = 0.001. The mean post-test score was significantly higher in the BL groups than in the ND groups, with a mean difference of 20.290, 95% CI [7.519, 33.016], p = 0.002 (see Figure 4).

Standard multiple regression

A multiple regression was run to predict conservation post-test scores from children's age and conservation pre-test scores. The multiple regression model statistically significantly predicted conservation post-test scores, [$F_{(2,\ 57)}$ = 87.21, $p < 0.001$, adj. R^2 = 0.75]. Both variables added statistical significance to the prediction, $p < 0.05$. Regression coefficients and standard errors can be found in Table 4.

Conflict resolution knowledge

Descriptive statistics

The descriptive statistics for the conflict resolution pre-test scores revealed differences in the five groups that included the non-conserver dominant K2 group (n = 8), the balanced K2 groups (n = 16), the non-conserver dominant K3 group (n = 8), the balanced K3 groups (n = 16), and the balanced K2 + K3 groups (n = 16). It showed that the mean pre-test scores on conflict resolution tasks in the non-conserver dominant K2 group were 19.25 (SD = 4.06), in the balanced K2 groups, it was 20.81

TABLE 3 Descriptive statistics for pre-and post-test scores on conservation in the five groups.

			Pre-test		Post-test	
Expected difficulty ranking	Difficulty ranking	Conservation tasks	Mean	SD	Mean	SD
4	5	**Two-dimensional space task (maximum score = 6)**				
		BL + K2 groups (n = 16)	2.88	1.36	3.50	1.79
		BL + K3 groups (n = 16)	4.13	2.00	5.25	1.34
		BL + K2K3 groups (n = 16)	4.00	2.07	4.75	1.69
		ND + K2 group (n = 8)	2.88	1.64	2.75	1.39
		ND + K3 group (n = 8)	3.00	1.85	3.88	2.03
		All groups (n = 64)	3.48	1.85	4.20	1.82
2	2	**Number task (maximum score = 6)**				
		BL + K2 groups (n = 16)	3.38	1.67	3.75	1.84
		BL + K3 groups (n = 16)	5.00	1.79	4.63	1.46
		BL + K2K3 groups (n = 16)	4.00	2.07	4.63	1.63
		ND + K2 group (n = 8)	2.88	1.64	2.75	1.39
		ND + K3 group (n = 8)	3.00	1.85	3.38	1.92
		All groups (n = 64)	3.83	1.85	4.20	1.82
6	8	**Weight task (maximum score = 6)**				
		BL + K2 groups (n = 16)	2.75	1.34	3.06	1.65
		BL + K3 groups (n = 16)	3.50	2.00	4.81	1.47
		BL + K2K3 groups (n = 16)	3.75	1.88	4.19	1.87
		ND + K2 group (n = 8)	2.00	0.00	2.00	0.00
		ND + K3 group (n = 8)	2.00	0.00	2.75	1.49
		All groups (n = 64)	3.00	1.64	3.61	1.79
1	3	**Substance task (maximum score = 6)**				
		BL + K2 groups (n = 16)	4.50	2.00	4.94	1.29
		BL + K3 groups (n = 16)	3.50	1.87	4.96	1.60
		BL + K2K3 groups (n = 16)	4.44	1.97	4.38	1.93
		ND + K2 group (n = 8)	2.38	1.06	2.38	1.06
		ND + K3 group (n = 8)	2.75	1.49	2.88	1.64
		All groups (n = 64)	3.67	1.89	3.84	1.80
3	4	**Continuous quantity task (maximum score = 6)**				
		BL + K2 groups (n = 16)	4.25	2.05	4.94	1.53
		BL + K3 groups (n = 16)	3.25	1.85	4.79	1.72
		BL + K2K3 groups (n = 16)	4.00	2.07	4.44	1.97
		ND + K2 group (n = 8)	2.00	0.00	2.00	0.00
		ND + K3 group (n = 8)	3.00	1.85	3.50	2.07
		All groups (n = 64)	3.55	1.90	3.97	1.89
5	5	**Discontinuous quantity task (maximum score = 6)**				
		BL + K2 groups (n = 16)	4.38	1.96	5.13	1.31
		BL + K3 groups (n = 16)	3.42	1.91	4.63	1.77
		BL + K2K3 groups (n = 16)	4.00	2.07	4.13	1.96
		ND + K2 group (n = 8)	2.00	0.00	2.00	0.00
		ND + K3 group (n = 8)	3.00	1.85	2.88	1.64
		All groups (n = 64)	3.48	1.89	3.80	1.85

(Continued)

TABLE 3 (Continued)

Expected difficulty ranking	Difficulty ranking	Conservation tasks	Pre-test		Post-test	
			Mean	SD	Mean	SD
7	7	**Area task (maximum score = 18)**				
		BL + K2 groups (n = 16)	5.50	6.99	10.56	7.23
		BL + K3 groups (n = 16)	1.63	4.24	9.21	7.14
		BL + K2K3 groups (n = 16)	5.38	6.68	9.13	8.56
		ND + K2 group (n = 8)	0.00	0.00	0.00	0.00
		ND + K3 group (n = 8)	3.00	6.41	2.75	5.75
		All groups (n = 64)	3.19	5.77	5.58	7.39
8	1	**Length task (maximum score = 18)**				
		BL + K2 groups (n = 16)	1.06	4.25	2.63	5.24
		BL + K3 groups (n = 16)	6.94	7.98	11.63	7.07
		BL + K2K3 groups (n = 16)	7.69	8.08	9.38	8.64
		ND + K2 group (n = 8)	0.00	0.00	0.00	0.00
		ND + K3 group (n = 8)	3.00	6.41	3.75	6.96
		All groups (n = 64)	4.30	7.03	6.38	7.85
		Conservation tasks (maximum score = 72)				
		BL + K2 groups (n = 16)	20.31	12.00	24.88	16.30
		BL + K3 groups (n = 16)	38.19	22.75	51.88	20.47
		BL + K2K3 groups (n = 16)	37.25	24.49	45.00	26.93
		ND + K2 group (n = 8)	14.13	3.94	13.88	3.18
		ND + K3 group (n = 8)	22.75	21.08	25.75	21.39
		All groups (n = 64)	28.55	21.03	35.39	24.06

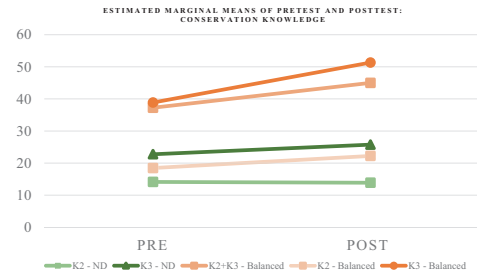

FIGURE 4
The comparison of children's conservation in pre-test and post-test.

(SD = 3.15), in the non-conserver dominant K3 group it was 20.63 (SD = 3.42), in the balanced K3 groups it was 19.69 (SD = 3.24). In the balanced K2 + K3 groups, it was 19.25 (SD = 3.44).

Descriptive statistics for the conservation post-test scores revealed differences in the five groups. It showed that the mean score of children's post-test scores on conservation tasks in the non-conserver dominant K2 group was 18.63 (SD = 2.50). In the balanced K2 groups, it was 22.13 (SD = 3.05); in the non-conserver dominant K3 group, it was 20.63 (SD = 3.46); in the balanced K3 groups, it was 21.38 (SD = 3.03); and in the balanced K2 + K3 groups, it was 21.75 (SD = 1.88).

Overall, the children's improvement in the conflict resolution tasks from the pre-test to the post-test was significant [t (63) = −3.83, $p < 0.01$], and the effect sizes were negligible for all groups (d = −0.48).

The descriptive statistics above indicated that the children in the balanced K2 + K3 groups made the most significant progress in constructing conflict resolution knowledge from the pre-test to the post-test, followed by those in the balanced K3 groups. In addition, the children in the balanced K2 groups progressed in comprehending conflict resolution knowledge. The scores of children in the non-conserver dominant K2 group and non-conserver dominant K3 group in the pre-test and post-test did not appear to have distinct differences (see Table 5).

Three-way mixed ANOVA

A three-way mixed ANOVA was run to understand the effects of age group, conserver dominance, and time on the children's construction of conflict resolution knowledge. The three-way interactions between time, age group, and conserver dominance were not statistically significant while controlling for gender and class, [$F_{(1,56)} = 0.392$, $p = 0.534$]. There was a statistically significant two-way interaction between time and conserver dominance, [$F_{(1,56)} = 6.142$, $p < 0.05$, $\eta^2 p = 0.099$]. There was no time effect based on age group for children in the same group, [$F_{(2,56)} = 1.261$, $p = 0.291$]. There was no additional two-way interaction between

TABLE 4 Multiple regression results for conservation post-test scores.

Conservation post-test scores	*B*	95% CI for B		SE B	β	R^2	ΔR^2
		LL	UL				
Model						0.75	0.75***
Constant	−33.42	−67.02	0.17	16.78			
Age	7.88*	1.48	14.27	3.19	0.19*		
Conservation pre-test scores	0.86***	0.68	1.03	0.09	0.76***		

*$p < 0.05$. ***$p < 0.001$.

age group and conserver dominance, [$F_{(1,56)} = 0.644$, $p = 0.426$]. There was a statistically significant main effect of conserver dominance [$F_{(1,61)} = 5.046$, $p < 0.05$, $\eta^2 p = 0.076$] on children's construction of conflict resolution knowledge (see **Figure 5**).

Standard multiple regression

A multiple regression was run to predict conflict resolution post-test scores from children's age and conflict resolution pre-test scores. The multiple regression model statistically significantly predicted conflict resolution post-test scores, [$F_{(2,\ 60)} = 16.96$, $p < 0.001$, adj. $R^2 = 0.34$]. The conflict resolution pre-test scores added statistical significance to the prediction, $p < 0.001$. Regression coefficients and standard errors can be found in **Table 6**.

Discussion

Introduction

The current study examined the effect of age groups and conserver dominance on children's knowledge construction. The summative conclusions of the research questions, hypotheses, and findings are presented in **Table 7** below.

How do children construct conservation knowledge?

Constructing conservation in mixed-age groups

The findings of the three-way mixed ANOVA indicated that children in K2 + K3 groups constructed conservation significantly better than children in K2 groups but not children in K3 groups. This result is partially consistent with the earlier research (Magnusson and Bäckman, 2022), which suggested that older children facilitated the learning of their younger peers in the mixed-age group discussions, promoting younger children's higher-order thinking skills and cognitive development. In the meantime, this result partially corroborated the previous studies (White et al., 1976; Basargekar and Lillard, 2021), which argued that there was no difference between mixed-age groups and conventional groups in the conservation construction. Moreover, the standard multiple regression further supports the findings above by indicating that children's age significantly predicted their construction of conservation. Compared to K2 children, K3 children showed a better performance when resolving the conservation tasks, which explains why children in K3 groups constructed conservation better than children in K2 + K3 groups.

The children in the mixed-age groups showed a positive influence of peer modeling in knowledge construction. For example, Child A and Child B were K3 conservers, and Child C and Child D were K2 non-conservers, and they were discussing how to measure the amount of flour in the story. Child C thought the flour could be measured with a ruler, and Child A told her the ruler could only be used to measure straight lines. Child D said the twin brothers could put the flour on the table, and the one with more space had more flour. Child A told him that placing the flour on the table could have been better because it could have made a mess everywhere. Then, Child A thought the scale could help measure the flour. Child B agreed with Child A's idea and argued that the twin brothers could find two long cups and put the flour inside to see if the heights were the same.

In addition, the results indicated that, although there was no comparison between the high-ability children's different interaction situations, it was evident that the conservers in the K2 + K3 groups did not reveal any significant progress in constructing the conservation knowledge after interacting with their younger peers. This result did not support that of Skon et al. (1981), who argued there was no difference in whether children communicated with peers of similar or different abilities. However, this finding accorded with that of Rouse (2015), who concluded that older children's learning could be negatively affected by their younger peers in mixed-age interactions.

Constructing conservation in groups with more competent peers

The results of the three-way mixed ANOVA demonstrated that, compared with the children in the non-conserver dominant (ND) groups, those in the balanced (BL) groups made significant progress in constructing conservation. This result supports previous literature (Rosenthal and Zimmerman, 1972; Mazur, 2015) that indicates that when conservers and non-conservers confront each other to reach an agreement on the judgment of a series of conservation problems in a social conflict situation, the concept of conservation is obtained. In addition, the findings of the standard multiple regression further clarified that children's pre-test conservation score significantly predicted their post-test score of conservation, which indicated that the groups with more competent peers could construct conservation better.

The equal number of conservers and non-conservers in the BL groups created more chances for non-conserving children to interact with conserving children, which is essential for the development of children's logical-mathematical thinking and their conceptualization and feedback about the validity of logical constructions (Piaget, 1926). Moreover, empirical studies have further identified (Ames and Murray, 1982; Moessinger,

TABLE 5 Descriptive statistics for pre-and post-test scores on conflict resolution in the five groups.

	Pre-test		Post-test	
Conflict resolution tasks	Mean	SD	Mean	SD
What if a friend will not play with you? What do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	3.38	1.41	3.50	1.16
BL + K3 groups (n = 16)	3.25	1.26	3.75	0.57
BL + K2K3 groups (n = 16)	3.13	1.50	3.56	1.09
ND + K2 group (n = 8)	2.88	1.46	2.88	1.46
ND + K3 group (n = 8)	3.75	0.46	3.13	0.99
All groups (n = 64)	3.27	1.28	3.45	1.05
Let us think about a situation where another child teases you; what do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	2.94	1.24	3.75	0.68
BL + K3 groups (n = 16)	2.75	0.93	3.50	0.89
BL + K2K3 groups (n = 16)	2.75	1.44	3.38	0.81
ND + K2 group (n = 8)	2.75	1.49	2.63	0.92
ND + K3 group (n = 8)	3.13	0.99	3.25	0.89
All groups (n = 64)	2.84	1.20	3.39	0.87
What if you see some children quarreling with each other? What do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	4.00	0.00	4.00	0.00
BL + K3 groups (n = 16)	3.88	0.50	4.00	0.00
BL + K2K3 groups (n = 16)	3.56	1.09	4.00	0.00
ND + K2 group (n = 8)	3.75	0.71	3.63	0.74
ND + K3 group (n = 8)	3.88	0.35	4.00	0.00
All groups (n = 64)	3.81	0.66	3.95	0.28
Let us think you are playing a game with somebody, and the other does not follow the rules. What do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	3.50	1.16	3.50	0.82
BL + K3 groups (n = 16)	3.17	1.44	3.71	0.91
BL + K2K3 groups (n = 16)	3.50	1.16	3.75	0.68
ND + K2 group (n = 8)	3.75	0.71	3.50	0.93
ND + K3 group (n = 8)	3.50	0.93	3.75	0.71
All groups (n = 64)	3.55	0.98	3.66	0.74
What if you are doing important work and somebody (another child) comes to disturb you? What do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	3.31	1.20	3.50	0.73
BL + K3 groups (n = 16)	2.94	1.00	3.50	0.82
BL + K2K3 groups (n = 16)	2.94	1.00	3.56	0.73
ND + K2 group (n = 8)	3.00	0.93	3.00	0.54
ND + K3 group (n = 8)	2.88	0.99	3.25	0.89
All groups (n = 64)	3.03	1.02	3.42	0.75
What if somebody takes your toy? What do you do? (maximum score = 4)				
BL + K2 groups (n = 16)	3.63	0.72	3.63	0.72
BL + K3 groups (n = 16)	3.38	0.96	3.50	0.73
BL + K2K3 groups (n = 16)	3.38	0.81	3.71	0.62
ND + K2 group (n = 8)	3.13	0.99	3.00	0.93
ND + K3 group (n = 8)	3.50	0.93	3.25	0.89
All groups (n = 64)	3.42	0.85	3.34	0.84

(Continued)

TABLE 5 (Continued)

Conflict resolution tasks	Pre-test		Post-test	
	Mean	SD	Mean	SD
Conflict resolution tasks (maximum score = 24)				
BL + K2 groups (n = 16)	20.81	3.15	22.13	3.05
BL + K3 groups (n = 16)	19.69	3.24	21.38	3.03
BL + K2K3 groups (n = 16)	19.25	3.44	21.75	1.88
ND + K2 group (n = 8)	19.25	4.06	18.63	2.50
ND + K3 group (n = 8)	20.63	3.42	20.63	3.46
All groups (n = 64)	19.92	3.35	21.22	2.91

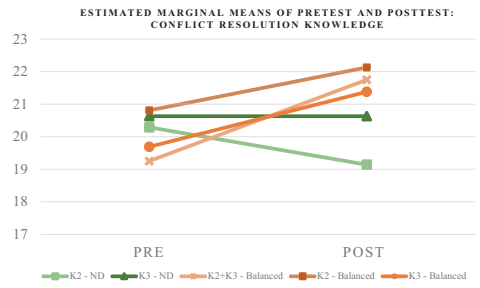

FIGURE 5
The comparison of children's conflict resolution in pre-test and post-test.

2009; Osborne, 2010) that non-conservers develop and maintain the concept of conservation when working and interacting collaboratively with conservers. By incorporating the reciprocal characteristics of peer interactions and the significant role of communication, children's logical thinking and cognitive development can occur within effective peer-learning contexts and the classroom setting (Gillies, 2014; Sills et al., 2016).

We can see clearly how the interactions between conservers and non-conservers affected the non-conservers' development of conservation concepts in the current study. For example, Child A was a conserver, and Child B was a non-conserver, and they were discussing why it turned out that the twin brothers had the same amount of flour in the story. Child B thought it was because the flour was poured into identical cups, and Child A told Child B that the twin brothers had the same amount of flour at the beginning. Child B asked Child A for a reason, so Child A explained that the amount of flour looks different because the shape of plastic bags is different, but the amount of flour is the same.

How do children construct conflict resolution knowledge?

Constructing conflict resolution in mixed-age groups

The findings of the three-way mixed ANOVA indicated that children in K2 + K3 groups constructed conservation better than children in K2 and K3 groups, although the results were not significant. One possible reason is that the instrument measuring children's conflict resolution only contained six scenarios, which may have affected the knowledge assessment and thus may not have been able to generate remarkable results. The finding supports preliminary studies (Lillard, 2012; Wu et al., 2022), which claimed that compared to conventional groups, children in the mixed-age groups showed more significant gains in social problem-solving and significantly more positive peer interactions. Moreover, the standard multiple regression indicated that children's age did not predict their performances on conflict resolution tasks in the post-tests, which demonstrated that older children may not be socially more mature than younger children. This result differs from the previous studies (Blair et al., 2015; Roskam et al., 2017), which demonstrated that older children exhibited higher levels of social competence, emotion regulation, and ability to resolve peer conflicts.

King et al. (2018) stated that positive peer interactions support children's social adaptive development and mental wellbeing and adjust problematic behaviors in social-conflict situations. Interactions with peers in different age groups also alter children's self-regulation, which controls and redirects their emotions and behaviors to reach a concurrence (Blair and Raver, 2015). For example, when discussing what you would do if your peer did not follow the rule, Child A (K2) thought telling the teacher what happened was a good solution, but Child B (K3) believed they could try to solve the problem themselves. Child A asked if he had a better solution, and then Child B said he would tell the peer about the rule again, but if the peer kept breaking the rule, he would ask for the teacher's help.

Constructing conflict resolution in groups with more competent peers

The results of the three-way mixed ANOVA revealed that children in the balanced (BL) groups constructed conflict resolution better than children in the non-conserver dominant (ND) groups. The findings of the standard multiple regression also identified that groups with more conservative children showed a significantly better performance when constructing conflict resolution in the post-tests. There are similarities between this finding and those described by Deutsch et al. (2011), which demonstrated that group members with more power in the analysis based on their current knowledge, perspectives, and

TABLE 6 Multiple regression results for conflict resolution post-test scores.

Conflict resolution post-test scores	*B*	95% CI for B		SE B	β	R^2	ΔR^2
		LL	UL				
Model						0.36	0.34***
Constant	−10.86	4.23	17.48	3.31			
Age	−0.02	−1.01	0.98	0.50	−0.003		
Conflict resolution pre-test scores	0.52***	0.35	0.71	0.09	0.60***		

***$p < 0.001$.

TABLE 7 Summative conclusions of the research questions, hypotheses, and findings.

Research questions	Hypotheses	Findings
Summative conclusions		
RQ 1: Do children in mixed-age groups construct conservation and conflict resolution better than other groups?	H1a: Children in the mixed-age groups construct conservation better.	Partially supported
	H2a: Children in the mixed-age groups construct conflict resolution better.	Not supported
RQ 2: Do children in groups with more competent peers perform better in constructing conservation and conflict resolution than other groups?	H1b: Children in groups with more competent peers construct conservation better.	Supported
	H2b: Children in groups with more competent peers construct conflict resolution better.	Supported

experiences tend to have more confidence when solving social problems.

Children with higher cognitive reasoning strategies and a better understanding of opposing perspectives tend to engage other group members in the collaborative learning environment. This leads the group to seek concurrence on the social controversy under discussion (Piaget, 2009; Zwiers and Crawford, 2023). The assistance offered by high-ability children is a valuable educational tool to help other children acquire appropriate social skills and produce positive changes in social behaviors (Alegre et al., 2019).

In the current study, for example, when discussing what you would do if someone took your toy, Child A, a non-conserving child, said he would take it back immediately. Child B, a conserving child, had the opposite view that it was easy to get into a fight like the twin brothers did in the storybook. Child A argued that he just wanted to take the toy back, and Child B said it was better to reason things out by telling the child it was not good to take another's toy without permission.

Conclusion

Summative conclusion

The current study demonstrated that a mixed-age learning environment had a limited impact on children's knowledge construction. Children in the mixed-age groups showed ability in comprehension, explanation, and extension of conservation and conflict resolution tasks. Still, the difference between mixed-age and same-age groups was not prominent. In addition, compared with those in the non-conserver dominant groups, children in the balanced groups tended to be more able to understand the concepts of conservation conceptually, and they adopted more open and participative attitudes when encountering peer conflicts.

Implications

Theoretically speaking, the current study discussed the benefits of interactions with peers. It has been identified in the previous survey (Lillard et al., 2017) that mixed-age grouping, where children can work with developmentally suitable peers, promotes children's cognitive and social development. The current study added empirical evidence to the literature by indicating the moderate influence of mixed-age grouping on children's knowledge construction, especially for older children's development. Moreover, while the positive influences of interacting with high-ability peers on children's development have been emphasized (Bowman-Perrott et al., 2013), the current study further demonstrated that having more opportunities to interact with more competent peers accelerated children's knowledge construction, which provided new insights into peer learning and development.

Practically speaking, the current study's design resembles multi-age grouping in Montessori classrooms, where children of different ages and abilities participate in group discussions and collaborative activities to solve problems together (Isaacs, 2018). Based on the positive results revealed from the current study, the Montessori learning mode is recommended to implement. Furthermore, the teacher's active and sensitive involvement and guidance in learning (Howe et al., 2019) cannot be underestimated. Teachers' scaffolding can provide intentional and responsive support for children to learn new concepts and skills and develop more profound thinking

and understanding (Bakker et al., 2015). We suggested that teachers can facilitate peer interactions by using open-ended questions and collaborative tasks, encouraging children to share their viewpoints, and maintaining continuous back-and-forth exchanges of information (Karuppiah, 2021).

Limitations

There were some limitations of this study. Even though the children's improvements in conservation and conflict resolution knowledge suggested the potential effects of cross-level age groups and conserver dominance, the interaction of the age group and conserver dominance did not show any significant effects. The non-significant interaction effects may be attributed to the small sample size, making detecting the effects in direct inter-group comparisons challenging.

Also, the participating children came from a convenient sampling process, so the same participants were involved in both experiments. Although gender and grade level were controlled well in the experiments, the results from the present sample cannot be generalized to children from more diverse backgrounds.

Moreover, the sample in the current study was collected from one kindergarten, which limits the generalization of the results to another context. The kindergarten in which the study was based features Montessori education; thus, the average level of children's cognitive and social development might deviate from that of children in conventional kindergartens. The results of the current study may not be generalized to most kindergartens in China.

Future research suggestions

One of the possible directions for future research in this field is to enhance the teacher's role during peer interactions. Urbani (2019) acknowledged that teachers who receive proper training can support children's linguistic development and language achievements. In addition, teachers may have more experience in classroom management and curriculum design. Thus, training teachers to scaffold peer interactions and co-construction of conservation and conflict resolution knowledge could benefit children's long-term development. Future studies can further compare children's learning outcomes of conservation and conflict resolution during peer interactions with or without the scaffolding of trained teachers. Another possible direction for future research is to involve e-books to facilitate children's interactions and learning with peers. Digital technology has been widely normalized by the younger generation and fully integrated into their daily lives (Schriever, 2018). E-books allow children to learn via multimedia approaches such as written text, oral reading and discourse, music and animation to enhance language learning and comprehension (Egert et al., 2022). Therefore, future studies can further compare children's construction of conservation and conflict resolution knowledge during peer collaborative learning with or without e-books.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Human Research Ethics Committee (HREC) of The Education University of Hong Kong. The studies were conducted in accordance with the local legislation and Institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

XW: Writing – original draft, Validation, Methodology, Investigation, Formal Analysis, Data curation, Conceptualization. JK: Writing – review and editing, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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