




Early cognitive intervention using mediated learning for preschoolers with developmental delay: A randomized controlled trial

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Background. The use of mediated learning in cognitive training has been shown to be effective in enhancing students' cognitive development. Nonetheless, its effects on language development are less explored.

Aims. This study examined the effects of an early cognitive intervention (Think Bright program) in enhancing the cognitive and language development of Hong Kong preschoolers with developmental delay.

Method. Sixty-eight children (48 boys and 20 girls; mean age = 58 months) with developmental delay were recruited from preschool rehabilitation centres and randomized to two groups (Think Bright training vs. active control). Each child in the Think Bright group received 12 sessions of 1-hr individual training on thinking skills over 6 months. The control group received the same amount of training based on the regular training regimen adopted at the rehabilitation centres.

Results. After a 6-month intervention, the Think Bright group significantly outperformed the control group in language, general cognition, analogical thinking, sequential thinking, and logical reasoning. The Think Bright teachers' mediation skills significantly improved during the course of intervention and correlated moderately with the improvement in students' language abilities.

Conclusion. This study has shown promising results on the effectiveness of using mediated learning in early cognitive intervention in enhancing both the cognitive and language development of preschoolers with developmental delay.

Developmental delay describes children in early formative years exhibiting delayed development in one or more domains, including cognitive, language, physical, social–emotional, or adaptive skills (Shevell, Majnemer, Rosenbaum, & Abrahamowicz, 2001; Smith, 2006). Approximately 12–15% of the children in the United States experience developmental delay (Hirai, Kogan, Kandasamy, Reuland, & Bethell, 2018). According to the Child Assessment Service of the Department of Health in Hong Kong, about 15% of the newly referred cases were subsequently diagnosed with significant

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developmental delay or intellectual disability (Government of the Hong Kong Special Administrative Region, 2019). Language delay is the most common developmental problem and occurs with a high comorbidity with cognitive delay (Chuang et al., 2011). Preschoolers with developmental delays, in particular those with language impairments, are found to display lower academic performance, increased behavioural problems and social difficulties, as well as higher occurrence of psychiatric disorders in time (Dornelas et al., 2016; Perna & Loughan, 2013; Shevell, Majnemer, Platt, Webster, & Birnbaum, 2005). Early intervention for children with developmental delay is, therefore, crucial as it may reduce the incidence of developing other disorders (e.g. attention-deficit hyperactivity disorder) and enable the child to achieve better outcomes down the road (Doyle, Harmon, Heckman, & Tremblay, 2009; Hebbeler et al., 2007; Perna & Loughan, 2013).

Mediated learning and cognitive development

A growing body of literature has demonstrated that mediated learning is effective in enhancing the cognitive functioning of children with developmental problems (Lebeer, 2014; Lidz & Haywood, 2014; Murphy & Maree, 2006; Sternberg, 2014; Tzurriel, 2021; Tzurriel & Hanuka-Levy, 2014; Tzurriel & Shomron, 2018). Mediated learning is a structured approach to learning developed based on Feuerstein's theory of cognitive development (Feuerstein, Feuerstein, Falik, & Rand, 2006; Feuerstein & Feuerstein, 1991). Feuerstein posits two modalities of learning: a direct approach wherein children learn by interacting directly with stimuli in the environment, and a mediated approach which highlights the importance of adults' scaffolding in children's learning. More specifically, mediated learning involves an adult mediator – often a teacher or a parent – who interposes oneself between the child and the stimuli (i.e. objects, events, learning materials etc.), in order to facilitate the child's assimilation of the stimuli into their internalized cognitive structures. Feuerstein coined the term “mediated learning experience” (MLE) to describe this unique mentor–mentee interaction that presumably improves an individual's propensity to learn, by enabling the learners to become more aware of their own cognitive processes, acquire cognitive strategies, and develop learning behaviours that contribute to higher levels of functioning (Feuerstein et al., 2006; Feuerstein & Feuerstein, 1991).

Feuerstein proposed three essential characteristics that define all MLE interactions – intentionality, meaning, and transcendence (Feuerstein & Feuerstein, 1991). Mediation of intentionality involves communicating clearly to the child the purpose of the interaction, as well as maintaining the child's involvement in the interaction. To achieve this, the mediator needs to monitor the state of the child, including his/her vigilance and motivation levels, to render the child ready to engage in the interaction (Presseisen & Kozulin, 1992). It also requires the mediator to adapt the stimuli of learning via selecting, filtering, magnifying, or reducing them, to ensure clear registration of the stimuli by the learner. Mediation of meaning occurs when the mediator helps the child to acquire personal value and importance for engaging in a learning activity. This can be achieved through explicit teaching of cognitive skills and demonstrating their uses in problem solving, using verbal and non-verbal emphases and gestures to convey meaning, as well as acknowledging meaning expressed by the learners (Chua & Wong, 2016). The third criterion – mediation of transcendence – refers to the attempts of the mediator to move beyond the immediate goals of a particular interaction, to enable the child to apply the learning in different contexts and make connections with other related concepts. This

may involve exposing the learners to a range of situations that mandate the application of learning, explicitly connecting new concepts with previously learnt ones, asking “why” and “how” questions to assess learners’ thinking processes, and helping learners to generalize from specific instances to underlying rules (Chua & Wong, 2016).

Prior studies have shown that cognitive trainings based on Feuerstein’s theory of mediated learning are effective in enhancing the intellectual and behavioural functioning of preschool and school-aged children (Howie, 2015; Kozubík et al., 2018; Kozulin et al., 2010; Lebeer, 2016; McIntyre, 2017; Ricci, Assis, Nogueira, & Gotuzo, 2020; Todor, 2015; Tzuriel & Remer, 2018; Vedovelli, 2014). For instance, Instrumental Enrichment (IE) Basic (Feuerstein, Feuerstein, & Falik, 2009) is a teacher-mediated programme for children aged 3–8 and older individuals with cognitive deficiencies. It covers areas such as organization, analytic perception, comparison, classification, orientation in space and time and logical thinking that aim at developing the learners’ cognitive processes and metacognitive awareness needed to solve problems (Howie, 2015). Kozulin et al. (2010) examined the effectiveness of IE-Basic among children of mental ages 5–7 (mean chronological age = 106.9 months) with mild-to-moderate intellectual impairment and learning disabilities in five countries across North and South America, Europe, and the Middle East. Relative to active controls who received equivalent hours of occupational and sensory-motor therapy, the IE-Basic groups showed significantly greater improvement in fluid reasoning, but were comparable to the controls regarding gains in domain-specific crystallized intelligence. Other studies have also reported intervention effects on intelligence scores (Haywood, 2013; Howie, 2015), behavioural and social functioning (Kozubík et al., 2018; Todor, 2015), and less consistently on academic performance (Tzuriel et al., 2021; Vedovelli, 2014).

Mediated learning and language development

Feuerstein, Falik, Feuerstein, and Bohács (2013) argued that mediated learning does not merely enhance children’s cognitive development but also their language development via intentional and systematic use of language by the adult. Bruner (1966) also emphasized the importance of language as an instrument of thinking in mediation. Mediated learning encourages young learners to think aloud. Past studies have shown that a think-aloud procedure has positive effects on inference generation and text comprehension in children with language impairments (Gillam, Fargo, & Robertson, 2009; McClintock, Pesco, & Martin-Chang, 2014), presumably because engaging in the think-aloud might help reflect the children’s thoughts back to them in a way that shaped and benefited comprehension (McClintock et al., 2014; Sönmez & Sulak, 2018). The verbalization inherent to the think-aloud might also help transform inferences from implicit to explicit information, and thus enables the processing of relevant information to facilitate problem-solving (Baldo, Paulraj, Curran, & Dronkers, 2015; Carpendale, Lewis, Susswein, & Lunn, 2009; McClintock et al., 2014; Park, Korbach, & Brünken, 2020). Moreover, think-alouds also provide a window into children’s thinking, and enable the mediator to provide appropriate mediation.

We hypothesized that engaging in think-alouds and intellectual dialogues during the MLE interactions would likely advance children’s language development, which, in turn, increases their ability to construct meaning from complex, language-laden learning activities. The verbal exchange during MLE may also strengthen children’s reasoning and problem-solving abilities, by enabling them to think and communicate with precision, clarity, and coherence, and enhance their attention to details. Nevertheless, past studies

on cognitive interventions using MLE have seldom explored their effects on children's language development and its relations with improvement in thinking skills (e.g. Kozubík et al., 2018; Kozulin et al., 2010; Todor, 2015; Tzuriel et al., 2021; Vedovelli, 2014; for exception, see Tzuriel & Remer, 2018).

The present study

In Hong Kong, the preschool curriculum largely focuses on the development of basic academic skills, such as early literacy and numeracy, and rarely highlights the importance of teaching thinking skills among preschoolers. Preschool educators both in the regular and special education settings are generally not well equipped with the knowledge and pedagogical skills to teach thinking skills (Lam, Lim, Ma, & Adams, 2003). Mediated learning is also a novel idea to local preschool teachers who are used to a teacher-centred approach of teaching and learning which emphasizes how much subject matter knowledge is being taught in class. Based on findings on the effectiveness of using mediated learning in cognitive interventions for preschoolers with developmental delays (Kozulin et al., 2010; Lidz & Haywood, 2014; Murphy & Maree, 2006), we examined whether equipping preschool special education teachers in Hong Kong with mediated learning skills might facilitate improved language and cognitive outcomes in children with developmental delays via changes in teachers' pedagogical practices.

We conducted the Think Bright project to develop a locally adapted early cognitive intervention programme using mediated learning to address the training needs of preschoolers with developmental delay. The Think Bright intervention was adapted from existing mediated learning tools, including IE-Basic (Feuerstein et al., 2009), Children's Analogical Thinking Modifiability Test (Tzuriel & Klein, 1990), and Children's Conceptual and Perceptual Analogical Modifiability Test (Tzuriel & Galinka, 2000). It focused mainly on three types of activities: 1) analogical thinking, 2) sequential thinking, and 3) logical reasoning (Keung, Ho, Kwan, & Shum, 2018). *Analogical thinking* activities aim to enhance learner's ability to recognize common attributes and to infer categorical relations (e.g. the relation between bus and taxi is analogous to the relation between airplane and helicopter) and functional relations between objects (e.g. the relation between pencil and pencil case is analogous to the relation between books and school bag; Goswami, 2001). *Sequential thinking* activities promote the ability to recognize temporal relations between events (e.g. steps involved in hand washing) and to organize information in a logical sequence (Delgoshaei & Delavari, 2012). *Logical reasoning* activities require the ability to make comparison and use logic to discover absurdity or incongruity between situations and to problem solve (Feuerstein et al., 2009). These skills are in line with the developmental objectives for the intellectual development of preschoolers set out in the Hong Kong Kindergarten Education Curriculum Guide (Curriculum Development Council, 2017).

We conducted a randomized controlled trial on a community sample from preschool rehabilitation centres in Hong Kong to examine whether this type of early cognitive training might improve both thinking and language skills in preschoolers with developmental delay. We hypothesized that children's improvement in language would correlate with their improvement in thinking skills. Moreover, we posited that the implementation of Think Bright training would facilitate changes in pedagogical practices in the preschool special educators, and a stronger display of mediation skills by the teachers might be associated with larger improvements in the outcomes for the children.

Method

Participants and procedures

A total of 68 preschoolers (48 boys and 20 girls; mean age = 58 months) were recruited from 15 rehabilitation service centres in Hong Kong based on the following criteria: (1) children aged 48–60 months; (2) children diagnosed with cognitive and/or language delay or diagnosed with special needs and suspected by teachers to have cognitive/language delay; (3) children attending mainstream kindergartens while simultaneously receiving preschool rehabilitation services; and (4) parental agreement for their children to participate in this study in either the intervention group or active control group. Ethical approval was obtained from the Human Research Ethics Committee at the authors' institution and written consent was obtained from the parents prior to data collection.

Child participants were allocated to either the experimental group ($n = 34$) or the active control group ($n = 34$) through random assignment. This was conducted by the first author who assigned each participant with a random number generated by Excel; those with odd numbers were allocated to the experimental group and even numbers to the active control group. In the experimental group, 14 children had been previously diagnosed with both language and cognitive delay, 15 with language delay only, 4 with cognitive delay only, and 1 with other special educational needs; the corresponding numbers in the control group were 12, 17, 2, and 3 respectively. The experimental group received 12 sessions of individual cognitive training (i.e. Think Bright intervention) over 6 months, while the control group also received 12 individual sessions of regular training during this period. All individual sessions were 60 min each, conducted once every 2 weeks. Participants in both groups were assessed at baseline within 1 month prior to the training (Time 1) and immediately after the completion of the 6-month intervention (Time 2) to measure their language and cognitive abilities. All assessments were conducted individually by educational psychologists at the service centres. The CONSORT flow diagram is presented in Figure 1.

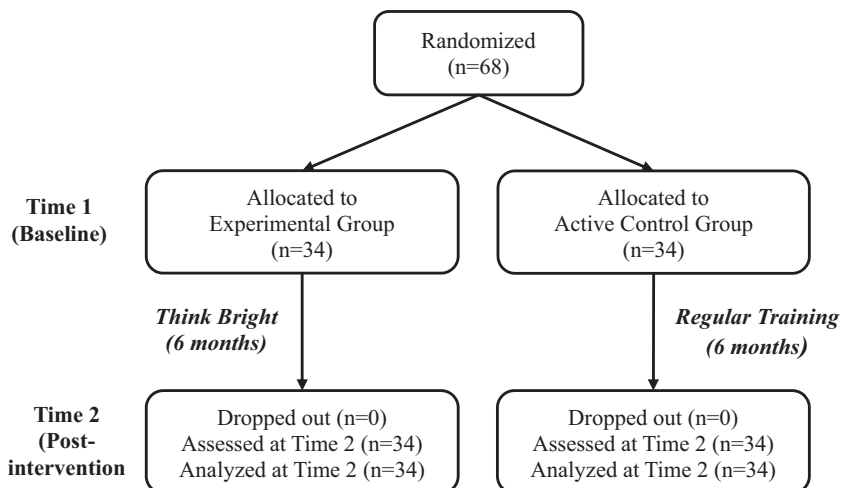


Figure 1. CONSORT flow diagram.

Experimental group: Think bright intervention

The Think Bright intervention was developed by Keung, Ho, Kwan, and Shum (2018) and included training activities that focused on: 1) analogical thinking, 2) sequential thinking, and 3) logical reasoning. Sample items of the training tasks are illustrated in Figure 2.

Analogical thinking

“Find the friends” comprised three subtasks on analogical thinking – Attribute Blocks, Categorical Analogy, and Functional Analogy, adapted from the Children’s Analogical Thinking Modifiability Test (Tzuriel & Klein, 1990) and Children’s Conceptual and Perceptual Analogical Modifiability Test (Tzuriel & Galinka, 2000). The *Attribute Blocks* task required children to observe and analyse the relation between two blocks in terms of

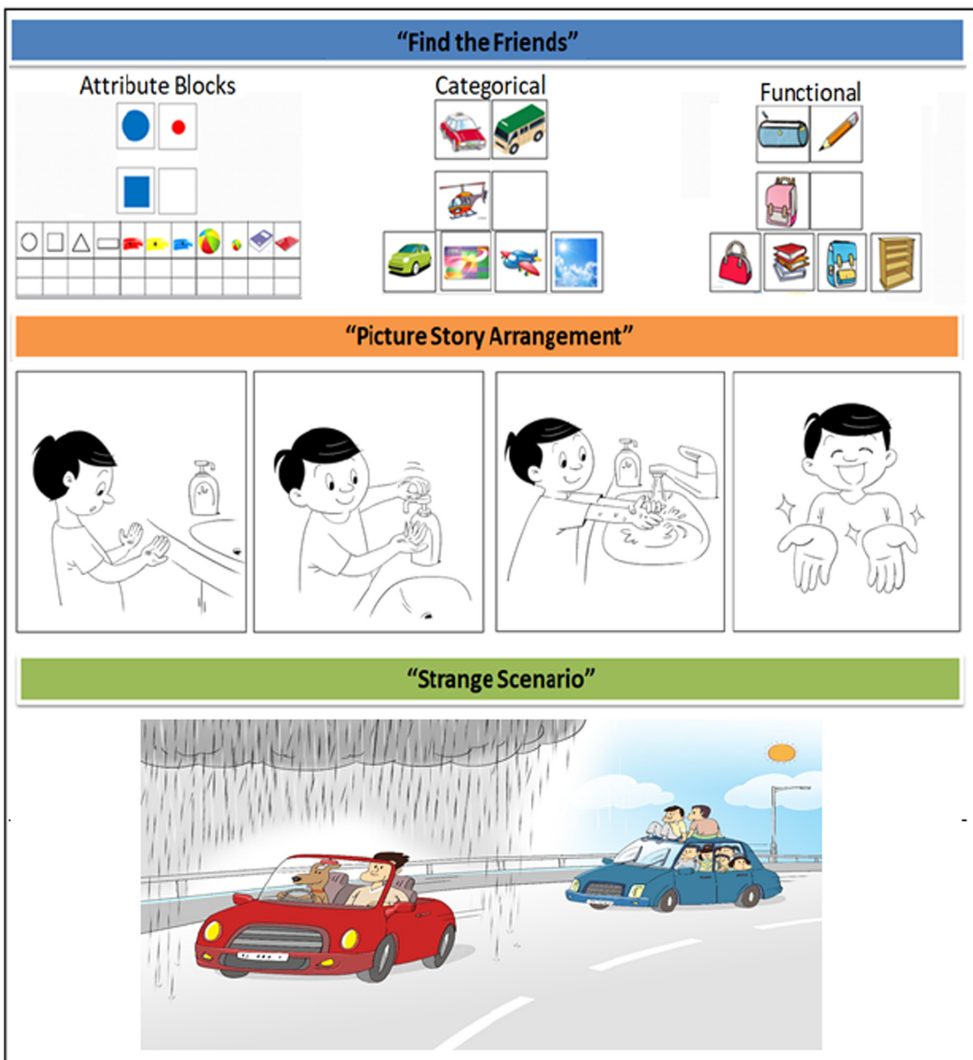


Figure 2. Sample items of the three types of training tasks in the Think Bright intervention.

colour, shape, size, and thickness and to subsequently find a block that matched the target block based on the relation between those attributes (Figure 2, top left). In the *Categorical Analogy* task, children were asked to observe and analyse the categorical relation between two objects and choose one from four alternatives to match the given target based on the inferred categorical relation (Figure 2, top middle). The *Functional Analogy* task was similar to the Categorical Analogy task, except that children needed to identify the functional relation between given object pairs and choose the correct match based on this inferred functional relation (Figure 2, top right). During the process, the teacher provided mediation to facilitate the child's systematic search for the correct answer through using specific sentence patterns and visual cards.

Sequential thinking

"Picture story arrangement" was an activity on sequential thinking developed by Keung et al. (2018) based on a similar task in the Learning Propensity Assessment Device (Feuerstein, Feuerstein, Falik, & Rand, 2002). It required children to construct and tell a meaningful story by ordering picture cards in a sensible sequence (Figure 2, middle panel). The teacher used mediation skills to guide the child to first identify the central theme of the story and to arrange the pictures in a logical sequence. The child was also encouraged to verbalize his/her ideas and to tell a story based on his/her own arrangement.

Logical reasoning

"Strange scenario" (Figure 2, bottom panel) was an activity on logical reasoning adapted from the Compare and Discover the Absurd Instrument of the Feuerstein Instrumental Enrichment Basic Program (Feuerstein et al., 2009). Children were asked to identify and describe the anomalies in a picture scenario. The teacher encouraged and assisted the child in conducting a systematic search of the anomalies, relating those anomalies to his/her own experiences in daily living, and justifying his/her own arguments.

Mediated learning process. Participants in the experimental group received 12 sessions of training. Mediated learning was conducted based on the recurring four-step process of "Explore-Try-Mediate-Conclude". In the first step ("explore"), the child was presented with a learning task while the teacher observed his/her methods of approaching the task. In the second step ("try"), the child was encouraged to try tackle the task, and to think aloud during the process. The teacher observed the child's problem-solving approach, encouraged the child to explain his/her attempts, and looked for any display of cognitive deficiencies. In the third step ("mediate"), the teacher provided mediation according to what was observed. For example, in the task of Attribute Blocks, if a child showed impulsive exploratory behaviour and failed to consider multiple sources of information (i.e. jumping to an answer by considering only the size of the given block but ignoring its colour, thickness, and shape), the teacher could mediate by guiding the child to analyse each attribute systematically and to think aloud and verbalize his/her findings, so that the processed information could be retained in awareness while he/she moved on to other information. In the final step ("conclude"), the child was asked to state the solution and describe the steps used to solve the problem. If the child had limited verbal skills to communicate, the teacher could mediate by modelling appropriate vocabularies and

providing scaffolding to help the child elaborate on his/her responses. Hence, the process of mediated learning involved a recurring cycle of the above steps – during which think-alouds were encouraged – with the objective to facilitate the child’s learning at his/her own pace without demanding for an absolute model answer.

Teachers’ training. Prior to the intervention, teachers received 6 hr of training conducted by the research team on how to administer the Think Bright program. The training covered the key components of mediated learning with video illustrations. This training also provided guidance to the teachers on how to teach thinking skills, through demonstrations and role-play practices with immediate feedback. The teachers learnt how to select training items that matched their students’ abilities, learning experiences, and interests. During intervention, on-site coaching was conducted by the research team for six out of the 12 training sessions to provide immediate consultation and feedback to the teachers. All training sessions were videotaped and coded for further monitoring of treatment integrity.

Active control group: Regular training

Regular training for the active control group was conducted by experienced teachers based on the standard training regimen adopted for preschoolers with developmental delay at the rehabilitation centres. It consisted of six types of cognitive skills – causal relations, spatial concepts, object concepts, colour concepts, shape concepts, and early mathematics concepts (Heep Hong Society, 2006). The learning tasks were highly structured, with specific procedures for giving instruction and error correction to ensure that the child achieved the specific learning goals. The child was guided to follow the example of the teacher and to use the same steps to reproduce the correct answer. The child’s abilities were judged based on how efficiently and independently he/she performed the tasks. Deviation from the prescribed steps or the use of other strategies were not encouraged. The quantity of learning (i.e. the percentage of curriculum being covered) was a priority in the regular training, and therefore the pace of teaching, as indicated by the number of learning tasks completed in each session, was faster than in the Think Bright training.

Measures of language and cognitive outcomes

Three types of outcome measures were included to assess: 1) language ability; 2) general cognition (including fundamental learning concepts), and 3) thinking skills in terms of analogical thinking, sequential thinking, and logical reasoning.

Language

The language subtest of the Hong Kong Comprehensive Assessment Scales for Preschool Children (HKCAS-P; Child Assessment Service, 2014) consists of 56 items on receptive and expressive vocabulary and grammar, and narrative comprehension and production. As reported in the technical manual of the HKCAS-P, this test correlated positively with the Reynell Developmental Language Scale (Hong Kong Society for Child Health & Development, 1987) and the Hong Kong Cantonese Oral Language Scales (Child Assessment Service, 2006). The internal consistency (KR-20) was .93, and test–retest

reliability was .91 (Wong, Leung, Siu, & Lam, 2012). We obtained a Cronbach's alpha of .88 based on the current sample.

General cognition

The cognitive subtest of the HKCAS-P (Child Assessment Service, 2014) consists of 35 items to assess the basic concepts of colour, shape, quantity, etc., and the cognitive abilities on matching, categorization, sequencing, and comparison. This test was reported in the manual to correlate positively with the Wechsler Preschool and Primary Scale of Intelligence-Revised (Wechsler, 2000). Internal consistency (KR-20) was .93 and test-retest reliability was .81 (Leung, Mak, Lau, Cheung, & Lam, 2013). We obtained a Cronbach's alpha of .86.

Verbal analogical thinking

The Similarities (SI) subtest of the Hong Kong Wechsler Intelligence Scale for Children (HK-WISC; Psychological Corporation, 1981) consists of 16 items to assess verbal analogical thinking. For the items on sentence completion, participants were required to complete the second sentence using a relational analogy similar to that given in the first sentence. For other verbal items, participants were read two words representing common objects or concepts, and asked to describe how they were similar. Reliability for this subtest was reported to be .57 and .67 for the age groups of 5 and 6 respectively (Psychological Corporation, 1981). We obtained a Cronbach's alpha of .79.

Non-Verbal analogical thinking

The Picture Concepts (PCn) subtest of the Wechsler Preschool and Primary Scale of Intelligence-Fourth Edition (WPPSI-IV; Wechsler, 2012) was used to measure non-verbal analogical thinking. Participants were presented with two or three rows of pictures and asked to select one picture from each row that they thought were related to each other. There were two sample items, followed by 27 test items. We obtained a Cronbach's alpha of .91 for this subtest.

Sequential thinking

The Picture Arrangement (PA) subtest of the HK-WISC (Psychological Corporation, 1981) was used to assess participants' sequential thinking. The PA subtest consists of three object/picture assembly items and nine story items. Participants were asked to rearrange picture cards to form an object, or a logical story. Reliability for this subtest was reported to be .77 and .79 for the age groups of 5 and 6 respectively (Psychological Corporation, 1981). We obtained a Cronbach's alpha of .68.

Logical reasoning

The Matrix Reasoning (MR) subtest of the WPPSI-IV (Wechsler, 2012) was used to measure fluid reasoning as a proxy to indicate an individual's ability to think logically and solve problems in novel situations. Participants were required to select a missing piece from several alternatives to complete a pattern in each item. There were three sample items, followed by 26 test items. We obtained a Cronbach's alpha of .91 for this subtest.

Video coding of think bright training sessions

Among the 12 training sessions for each participant in the Think Bright intervention, three sessions – the 2nd (at the beginning), the 6th (in the middle), and the 10th (towards the end) – were video-recorded and coded to assess the teachers' mediation skills. The process data provided information on the teacher–child interaction in the training sessions.

Measure of teachers' mediation skills during training

The mediation skills of teachers during Think Bright training were scored according to the Guidelines for Observing Teaching Interaction (GOTI; Lidz, 2003). This rating scale was developed based on Feuerstein et al.'s (2006) 12 parameters of MLE, and recommended for use by school psychologists with training in mediated learning to observe and provide feedback for teachers regarding their mediation skills in teacher–student interactions. There are 34 items categorized under the 12 parameters of MLE in the GOTI: Intent (3 items), Meaning (4 items), Transcendence (4 items), Joint Regard (2 items), Shared Experience (1 item), Task Regulation (8 items), Praise and Feedback (2 items), Challenge (1 item), Change (1 item), Differentiation (5 items), Contingent Responsivity (2 items), and Affective Involvement (1 item).

The rater was required to observe the entire training session and rate the occurrence of the skills as described by each item. All items on the GOTI were scored, except for item #25 on Contingent Responsivity (“Teacher is able to balance needs of higher performers with those of students with greater needs”), which was not applicable for one-on-one training. Each item was rated on a 4-point Likert scale: 1=skill not evident; 2=skill evident at an emergent level; 3=skill evident at a moderate level; and 4=skill evident at a high level. The highest possible score was 132 points (i.e. 33 items x 4 points).

Procedure for video coding

A total of 102 episodes of videos were coded by two educational psychologists. Inter-rater reliability was calculated by dividing the number of agreements by the total number of agreements and disagreements. An agreement was considered as an exact rating or a rating off by one (Tzuril & Samuels, 2000). To establish inter-rater reliability, the two raters independently coded 15 videos based on the GOTI. Scores of the two raters were compared, and a satisfactory level of agreement was reached (i.e. 97% = high agreement). Upon establishing a high inter-rater reliability, the remaining videos were then divided between the two raters, and each episode was coded by only one rater.

Statistical analysis

Sample size was determined based on a priori power analysis using G*Power 3.1.9.4 for analysis of covariance (ANCOVA) with two groups to detect medium effects. Assuming an effect size of $\eta_p^2 = .12$, a total sample size of 60 with 30 participants per condition was required to achieve power of .80 at a type I error rate of .05. Based on an anticipatory attrition rate of about 10–15%, we therefore recruited 68 participants to join this study.

Independent samples *t*-tests and Chi-squared tests were used to examine baseline differences in demographic characteristics between the experimental and control groups. One-way multivariate analysis of covariance (MANCOVA) was conducted to test for group difference in the overall training effect. *Post-hoc* analyses based on ANCOVAs were used

to indicate group difference in each outcome measure. To correct for multiple comparisons, the false discovery rate approach (FDR) was employed (Benjamini & Hochberg, 1995), and the adjusted p -values were calculated based on the following formula: adjusted $p_i = p_i N/i$, where p_i was the i^{th} smallest p -value out of N total p -values included. Hence, the adjusted p -value represented the expected number of false positives based on the p -value, divided by the number of positives accepted at that same p -value. While a p -value of .05 implied that 5% of all tests would result in false positives, an FDR adjusted p -value of .05 suggested that 5% of the significant tests would result in false positives. Correlations between improvement in outcome measures were examined. A repeated measures analysis of variance (ANOVA) was conducted to test for improvement in teachers' mediation skills across the sessions. Correlational analysis was conducted to examine the association between teachers' GOTI scores at the 10th training session and students' score improvement in the six outcome measures to identify if there was a dose-response relation.

Results

Baseline comparisons

The results of independent sample t -tests and Chi-squared tests showed no significant differences between the experimental and control groups in demographic characteristics (Table 1) and outcome measures at baseline (Table 2).

Intervention effects on child's language and cognitive outcomes

One-way MANCOVA was conducted to test for the group difference in the overall intervention effect. The independent variable was the intervention condition (experimental vs. control), and the dependent variables were the six outcome measures at Time 2

Table 1. Demographic characteristics of the participants, and baseline comparisons between the experimental and control groups

	Experimental ($n = 34$) Mean age (SD)/%	Control ($n = 34$) Mean age (SD)/%	t / χ^2	p -value
Age at pre-test (months)	59.71 (5.12)	58.88 (5.87)	.62	.54
Sex (%)				
Male	70.59	70.59	.00	1.00
Female	29.41	29.41		
Type of diagnosis (%)				
Cognitive delay	5.88	11.76	1.95	.58
Language delay	50.00	44.12		
Cognitive & language delay	35.29	41.18		
Other SENs	8.82	2.94		
Grade level (%)				
K1 (repeated)	2.94	0.00	1.03	.79
K2	47.06	50.00		
K3	44.12	44.12		
SCCC (ready to exit to K3)	5.88	5.88		

Note. SEN = special educational needs; SCCC = Special Child Care Centre.

Table 2. Means and standard deviations of the outcome variables at Time 1 and comparisons between the two training conditions

Variable (Max. score)	Time 1				t (66)	p
	Experimental (n = 34)		Control (n = 34)			
	Mean	SD	Mean	SD		
Language (68)	40.29	9.64	38.29	10.95	.80	.43
General cognition (40)	28.24	6.56	25.91	6.76	1.44	.16
Verbal analogical thinking (28)	5.06	3.29	3.88	3.49	1.43	.16
Non-verbal analogical thinking (27)	9.50	4.81	9.44	5.11	.05	.96
Sequential thinking (64)	8.24	4.00	10.32	6.72	-1.56	.12
Logical reasoning (26)	10.74	5.68	9.29	5.01	1.11	.27

– language, general cognition, verbal analogical thinking, non-verbal analogical thinking, sequential thinking, and logical reasoning – with age and Time 1 scores entered as the covariates. The overall intervention effect was statistically significant after controlling for age and baseline differences, $F(6, 54) = 9.17$, $p < .001$, Wilks' $\lambda = .50$, $\eta_p^2 = .51$, indicating a large effect size. Results of the *post-hoc* ANCOVAs for group differences in the respective outcome measures are shown in Table 3. Children in the experimental group showed significantly better performance than the control group at Time 2 in all six measures. Specifically, the experimental group outperformed the control group on language, general cognition, and logical reasoning with large effect sizes, and on analogical and sequential thinking with medium effect sizes ($\eta_p^2 > .06$ for medium effects; $\eta_p^2 > .14$ for large effects; Cohen, 2013). Figure 3 shows the mean scores of the treatment outcomes at Time 1 and Time 2.

Table 4 shows the effect sizes of the improvement in outcome measures from Time 1 to Time 2 for both groups expressed in Cohen's d . Cohen's d ranged from 0.72 to 1.22 for the experimental group, and 0.22 to 0.64 for the control group, indicating mostly large effect sizes (Cohen's $d > 0.8$) for the former but only small to medium effect sizes for the latter (Cohen, 2013). Overall, the effect sizes of the improvement in all outcome measures were larger for the experimental group than for the control group.

Correlations between improvement in language and cognitive skills

Difference scores between Time 1 and Time 2 of the outcome measures were calculated, and Pearson correlation coefficients between the difference scores are shown in Table 5. Improvement in language from Time 1 to Time 2 was significantly associated with the improvement in general cognition, verbal analogical thinking, and logical reasoning, but not with non-verbal analogical thinking and sequential thinking.

Teachers' mediation skills observed in training

The mean score for each of the 12 components of GOTI (Lidz, 2003) was computed for the 2nd, 6th, and 10th sessions of the Think Bright training, representing training delivered at the beginning, in the middle, and at the end of the intervention respectively. As shown in

Table 3. Results of ANCOVAs comparing group differences in outcome variables at Time 2 after controlling for age and Time 1 scores

Variable (Max. score)	Time 2		Adjusted mean	SE	F (1, 59)	p	Adjusted p^a	Effect size (η_p^2)		
	Experimental (n = 34)								Control (n = 34)	
	Adjusted mean	SE							Adjusted mean	SE
Language (68)	49.44	.94	41.20	.94	35.11	<.001	<.001	.37		
General cognition (40)	33.34	.57	29.19	.57	24.23	<.001	<.001	.29		
Verbal analogical thinking (28)	7.48	.49	5.72	.49	5.83	.02	.02	.09		
Non-verbal analogical thinking (27)	13.88	.52	11.82	.52	7.25	.01	.02	.11		
Sequential thinking (64)	15.70	.99	12.62	.99	4.48	.04	.04	.07		
Logical reasoning (26)	16.57	.58	12.69	.58	20.87	<.001	<.001	.26		

^aAdjusted p values controlled for multiple testing based on the false discovery rate approach.

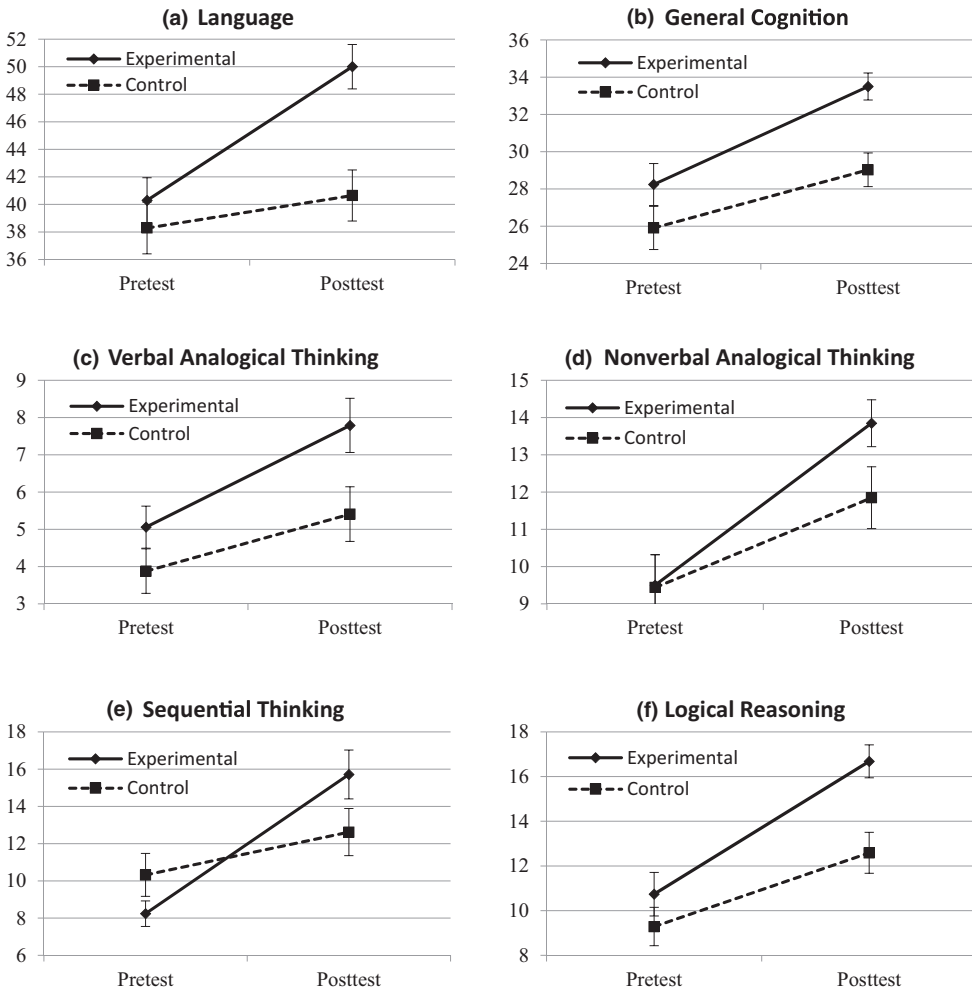


Figure 3. Mean scores and standard errors of the outcome variables at Time 1 and Time 2.

Table 4. Effect sizes (Cohen’s *d*) of the improvement in outcome measures from Time 1 to Time 2 for the experimental and control groups and their 95% confidence intervals (in brackets)

	Experimental (<i>n</i> = 34) <i>d</i> (95% CIs)	Control (<i>n</i> = 34) <i>d</i> (95% CIs)
Language	1.02 (.51, 1.52)	.22 (–.26,.69)
General cognition	.95 (.45, 1.45)	.50 (.01,.98)
Verbal analogical thinking	.72 (.23, 1.21)	.39 (–.09,.87)
Non-verbal analogical thinking	1.02 (.51, 1.52)	.48 (.00,.96)
Sequential thinking	1.22 (.70, 1.74)	.33 (–.15,.80)
Logical reasoning	1.18 (.66, 1.69)	.64 (.15, 1.12)

Figure 4, mediation skills were scored above the emergent level for all MLE components during the 2nd, 6th, and 10th sessions, indicating adequate adherence to the mediated learning approach throughout the intervention. Specifically, 9 out of the 12 components

Table 5. Pearson correlation coefficients between improvement in language and cognitive outcomes

	Language	General cognition	Verbal analogical thinking	Non-verbal analogical thinking	Sequential thinking	Logical reasoning
Language	-					
General cognition	.37**	-				
Verbal analogical thinking	.30*	.11	-			
Non-verbal analogical thinking	.22	.02	.21	-		
Sequential thinking	.23	-.07	.10	.08	-	
Logical reasoning	.31*	.22	.16	.07	.22	-

Note. * $p < .05$; ** $p < .01$.

were scored above 3 (evident at moderate level), and none were scored below 2 (evident at emergent level), even in Session 2 of the training.

A GOTI composite score was computed for each teacher–student dyad in each of the three sessions by summing the scores of all 33 items. Mean GOTI composite scores for the Think Bright teachers in the 2nd, 6th, and 10th sessions are shown in Figure 5. The mean GOTI score was found to improve in later training sessions compared to the second session. Repeated measures ANOVA showed that the mean GOTI scores significantly differed between sessions ($F[2, 66] = 3.19, p = .05, \eta_p^2 = .09$). Pairwise comparisons indicated a significant difference between the 2nd and the 10th sessions ($F[1, 33] = 5.26, p = .03, \eta_p^2 = .14$).

Pearson correlation coefficients between the GOTI score at the 10th session and the difference scores (T2–T1) for each outcome measure (Table 6) indicated that teachers' mediation skills correlated moderately with the children's improvement in language. This finding suggested a dose–response relation between mediated learning and language enhancement. In other words, the more mediation skills the teachers employed in their teaching, the greater improvement the students achieved in their language development.

Discussion

The Think Bright intervention enhanced the language performance and cognitive functioning of preschoolers with developmental delay in Hong Kong. Prior research on cognitive interventions using MLE have mostly examined intellectual and academic gains in terms of analogical reasoning ability, IQ points, scholastic aptitude scores, and literacy attainment (Cèbe & Paour, 2000; Kozulin et al., 2010; Molina & Vived, 2004; Tzuriel, Kaniel, Kanner, & Haywood, 1999; Tzuriel, Kaniel, Zeliger, Friedman, & Haywood, 1998; Tzuriel & Klein, 1985). To the best of our knowledge, very few studies have explored language gain as an outcome measure for these cognitive interventions (e.g. Kozubík et al., 2018; Kozulin et al., 2010; Todor, 2015; Tzuriel & Remer, 2018; Vedovelli, 2014). The present study provided evidence for the effectiveness of such intervention on cognitive enhancement as well as language development in young children with delays.

Improvement in cognitive performance

Early studies on the interaction between children's aptitudes and teachers' instructional approaches proposed that children with lower functioning benefited more from teacher-led direct instructions, whereas children with higher functioning responded better to interactive, child-directed teaching methods (Cole, Dale, & Mills, 1991; Snow, 1991). Later research, however, suggested that low performing students with special needs gained more from the cognitive-based interactive approach of mediated learning (Dale, Jenkins, Mills, & Cole, 2005; Eppley & Dudley-Marling, 2019).

Our results demonstrated that preschoolers with mild developmental delay benefited more from cognitive training when their teachers adopted the mediated learning approach, in contrast to those who received a similar amount of training conducted via a more teacher-centred approach. Specifically, children in the experimental group outperformed their counterparts in all the cognitive measures. Although significant improvements were observed in both groups at the post-test, the effect sizes of the improvements were about 2–3 times higher for the Think Bright group than the control group. The magnitude of the effect sizes (Cohen's d ranging from .72 to 1.22) obtained here was comparable to those indicated in previous studies on early cognitive programs using MLE (Cèbe & Paour, 2000; Howie, 2015; Kozulin et al., 2010; Molina & Vived, 2004). For instance, Molina and Vived (2004) reported effect sizes ranging from .70 to 1.07 on measures of general cognitive performance and IQ in preschoolers with Down Syndrome after completing a 2-year program. The effect sizes in our study were even larger than those obtained by Kozulin et al. (2010) among children with intellectual impairment who received 90 hr of IE-Basic (effect sizes ranged from .30 to .52).

It is noteworthy that while the tasks involved in the outcome measures of analogical thinking and sequential thinking were similar to the training activities in the Think Bright

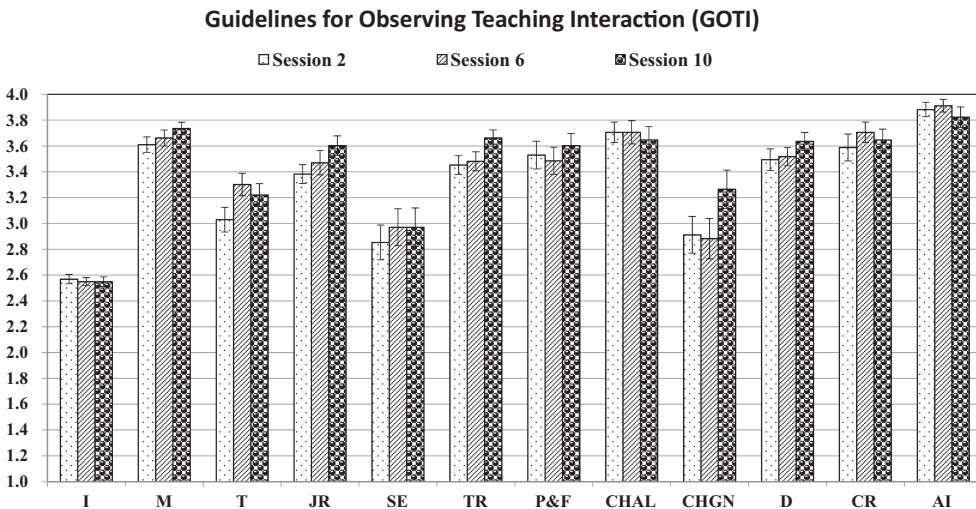


Figure 4. Teachers' mediation skills at Session 2, Session 6, and Session 10. GOTI scores at 1, 2, 3, and 4 denote teacher's mediation not evident yet, evident at emergent level, evident at moderate level, and evident at high level respectively. I= Intent; M=Meaning; T=Transcendence; JR=Joint Regard; SE=Shared Experience; TR=Task Regulation; P&F=Praise & Feedback; CHAL=Challenge; CHGN=Change; D=Differentiation; CR=Contingent Responsivity; AI=Affective Involvement.

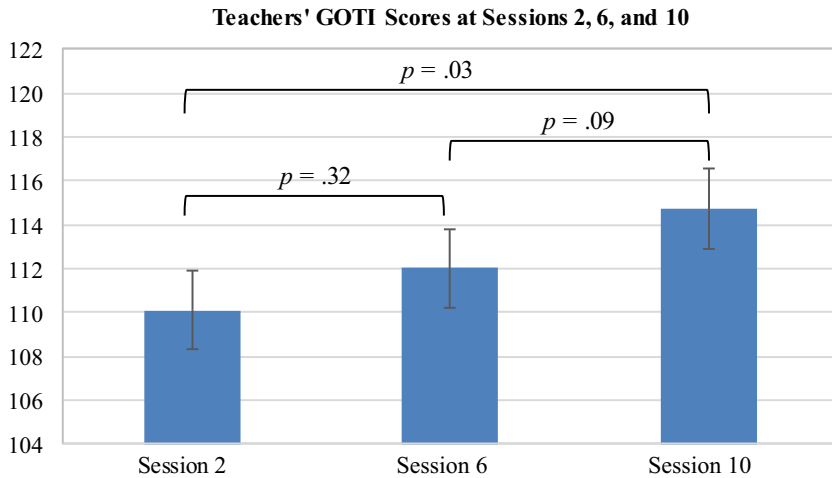


Figure 5. GOTI composite scores of the teachers in the experimental group at Sessions 2, 6, and 10.

programme, those measuring general cognition and logical reasoning did not closely resemble the training tasks. Nevertheless, the effect sizes on these thinking skills for the Think Bright group were comparably large, suggesting improvements not only in task-specific skills, but also broader generalizable skills such as problem-solving and non-verbal reasoning. The improvement of these thinking skills may likely enhance the children's learning abilities and adaptive functioning in their daily lives.

Improvement in language performance

Our results clearly showed that the Think Bright group improved not only in their thinking skills, but also in their language skills. Moreover, we observed a dose–response relation between mediated learning employed by the teachers and the extent of language improvement in the students, as well as significant correlations between language improvement and changes in general cognition, verbal analogical thinking, and logical reasoning. These results imply that language development is closely intertwined with the enhancement of thinking skills in mediated learning.

This finding corroborates the evidence from other empirical research supporting the facilitative role of language in thought and reasoning (e.g. Baldo, Bunge, Wilson, & Dronkers, 2010; Baldo et al., 2015; Kang, Jeong, Moon, Lee, & Lee, 2016; Lidstone, Meins, & Fernyhough, 2012). Vygotsky (1978, 2012) hypothesized that young children initially use overt speech and dialogues with elder peers or adults to work through problems, and eventually internalize overt speech into covert private speech. Studies on children and adults have shown that problem-solving performance is associated with language competence and the use of self-directed speech (Fernyhough & Fradley, 2005; Fox & Charness, 2010; Winsler, Fernyhough, & Montero, 2009). For instance, Fox and Charness (2010) showed that older adults performed better on matrix reasoning while thinking aloud. We postulated that the think-aloud strategy adopted in the MLE might have facilitated the teachers' mediation of the students' self-directed speech during the thinking process, which might become internalized in later problem-solving tasks. There were many occasions during the MLE for the students to verbally share their thoughts,

Table 6. Correlations between teachers' mediation skills at the 10th session and improvement in the outcome measures

	Language	General cognition	Verbal analogical thinking	Non-verbal analogical thinking	Sequential thinking	Logical reasoning
GOTI score (10th Session)	.35*	-.07	-.02	.00	.03	.24

Note. * $p < .05$.

reflect on how they arrived at a solution, and justify their answers. These were also windows of opportunities for the teachers to provide mediation on the children's cognitive processes and language expression. We posited that these elements of the MLE might have contributed to the considerable language and cognitive gains in the Think Bright group.

Improvement of teachers' mediation skills

Teachers delivering the Think Bright training demonstrated adequate mediation skills early in the intervention and maintained a satisfactory level of mediation skills throughout. Importantly, their mediation skills improved over the course of the intervention, suggesting that teachers became more skilful at mastering the techniques of mediated learning the more they practised using mediation.

Teachers' feedback was collected after the completion of the intervention. According to the teachers, their focus of teaching shifted from repetitive drills, eliciting model answers from students, and emphasizing quantity of teaching, to an accent on the quality of learning and students' motivation. During the intervention, the teachers were mindful that they should teach less but ask more questions to encourage students to think deeper. Teachers reported being more creative in their teaching after adopting the MLE, as they saw the need to improvise experiential learning with real-world relevance to enhance their students' understanding of concepts. They also regarded themselves as becoming more flexible and accommodating, and more readily following the students' lead and interests in their teaching. Teachers reported increased open-mindedness in accepting alternative reasonable answers other than model answers. This pedagogical shift in teachers, along with their high-quality mediation skills, might have resulted in the significant cognitive and language improvements observed in their students.

Limitations

Some limitations of this study should be highlighted. Firstly, given the small sample size in the current study, the generalizability of the results to other preschoolers with developmental delays remains to be explored. Secondly, the assessments were performed by educational psychologists who were not blinded to the experimental conditions. Although task administration was based on standardized procedures, script, and scoring schemes to minimize experimenter bias, the results should still be interpreted with caution. Thirdly, there were no comparisons of teachers' mediation skills between the experimental and control groups as training sessions of the latter were not video-

recorded. Moreover, the strength of the arguments presented might be discounted by the fact that the protocol was not pre-registered when we started the project in 2016. Preregistration of an intervention trial should be conducted to improve the transparency of the study.

Despite the finding of a dose–response relation between the teachers’ mediation and the extent of language improvement in the students, the current research design could not delineate the differential effects of the training tasks and teachers’ mediation on children’s language and cognitive gains. Future studies should further investigate the mechanisms of change by comparing the effects of applying the same training materials to preschoolers with and without adult scaffolding. Moreover, subsequent post-intervention follow-ups might provide more information on the long-term effects and sustainability of the intervention.

Conclusion

The Think Bright project was the first of its kind in Hong Kong. This study showed promising results with respect to the effectiveness of this early cognitive intervention program. The preschoolers in the Think Bright group displayed significantly larger improvement in language and thinking skills when compared to the control group. Moreover, the Think Bright teachers showed improved mediation skills and agreed that this programme allowed them to realize their students’ learning potentials through mediation.

Although this study was conducted in the preschool rehabilitation setting, we postulated that this training could also be implemented in the regular curriculum for teaching thinking skills among typically developing children. It is important to nurture the critical dispositions of good thinkers in young children, including traits such as open-mindedness, curiosity, attention to evidence, systematic thinking, and imaginativeness (Ritchhart & Perkins, 2004), and instilling in them the enjoyment of thinking (Robson, 2006). Future studies may explore the effectiveness of implementing the Think Bright programme in the mainstream curriculum for typically developing preschoolers.

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Author contribution

Alice YC Keung: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Writing – original draft. **Vania FL Ho:** Data curation; Project administration; Writing – review & editing. **Kathy Shum:** Conceptualization; Formal analysis; Methodology; Supervision; Writing – original draft; Writing – review & editing.

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Conflicts of interest

All authors declare no conflict of interest.

Data availability statement

The data that support the findings of this study will be openly available in the HKU Data Hub at <http://doi.org/10.25442/hku.14465079> upon acceptance of this paper.

References

- Baldo, J. V., Bunge, S. A., Wilson, S. M., & Dronkers, N. F. (2010). Is relational reasoning dependent on language? A voxel-based lesion symptom mapping study. *Brain and Language*, *113*(2), 59–64. <https://doi.org/10.1016/j.bandl.2010.01.004>
- Baldo, J. V., Paulraj, S. R., Curran, B. C., & Dronkers, N. F. (2015). Impaired reasoning and problem-solving in individuals with language impairment due to aphasia or language delay. *Frontiers in Psychology*, *6*, 1523. <https://doi.org/10.3389/fpsyg.2015.01523>
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, *57*(1), 289–300. <https://doi.org/10.1111/j.2517-6161.1995.tb02031.x>
- Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.
- Carpendale, J., Lewis, C., Susswein, N., & Lunn, J. (2009). Talking and thinking: the role of speech in social understanding. In J. I. M. Carpendale, C. Lewis, N. Susswein & J. Lunn (Eds.), *Private speech, executive function, and the development of verbal self-regulation* (pp. 83–94). Cambridge, UK: Cambridge University Press.
- Cèbe, S., & Paour, J. L. (2000). Effects of cognitive education in kindergarten on learning to read in primary grades. *Journal of Cognitive Education and Psychology*, *1*, 177–200. <https://doi.org/10.1891/194589500787383625>
- Child Assessment Service, Department of Health (2006). *Hong Kong Cantonese oral language assessment scale*. Hong Kong: Author.
- Child Assessment Service, Department of Health (2014). *Hong Kong comprehensive assessment scales for preschool children*. Hong Kong: Government Printer.
- Chua, B. L., & Wong, I. Y. F. (2016). *Mediated learning experience: Applications in various contexts*. Retrieved from: <https://repository.nie.edu.sg/handle/10497/18183>
- Chuang, Y. C., Hsu, C. Y., Chiu, N. C., Lin, S. P., Tzang, R. F., & Yang, C. C. (2011). Other impairment associated with developmental language delay in preschool-aged children. *Journal of Child Neurology*, *26*, 714–717. <https://doi.org/10.1177/0883073810389331>
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. New York, NY: Routledge.
- Cole, K. N., Dale, P. S., & Mills, P. E. (1991). Individual differences in language delayed children's responses to direct and interactive preschool instruction. *Topics in Early Childhood Special Education*, *11*(1), 99–124. <https://doi.org/10.1177/027112149101100110>
- Corporation, P. (1981). *Hong Kong wechsler intelligence scale for children manual*. New York, NY: Author.
- Curriculum Development Council (2017). *Kindergarten education curriculum guide*. Hong Kong: Education Bureau. <https://www.edb.gov.hk/en/curriculum-development/major-level-of-edu/preprimary/curr-doc.html>
- Dale, P. S., Jenkins, J. R., Mills, P. E., & Cole, K. N. (2005). Follow-up of children from academic and cognitive preschool curricula at 12 and 16. *Exceptional Children*, *71*(3), 301–317. <https://doi.org/10.1177/001440290507100306>
- Delgoshai, Y., & Delavari, N. (2012). Applying multiple-intelligence approach to education and analyzing its impact on cognitive development of pre-school children. *Procedia - Social and Behavioral Sciences*, *32*(C), 361–366. <https://doi.org/10.1016/j.sbspro.2012.01.054>

- Dornelas, L. F., Duarte, N. M., Morales, N. M., Pinto, R. M., Araújo, R. R., Pereira, S. A., & Magalhães, L. C. (2016). Functional outcome of school children with history of global developmental delay. *Journal of Child Neurology, 31*(8), 1041–1051. <https://doi.org/10.1177/0883073816636224>
- Doyle, O., Harmon, C. P., Heckman, J. J., & Tremblay, R. E. (2009). Investing in early human development: Timing and economic efficiency. *Economics & Human Biology, 7*(1), 1–6. <https://doi.org/10.1016/j.ehb.2009.01.002>
- Eppley, K., & Dudley-Marling, C. (2019). Does direct instruction work?: A critical assessment of direct instruction research and its theoretical perspective. *Journal of Curriculum and Pedagogy, 16*(1), 35–54. <https://doi.org/10.1080/15505170.2018.1438321>
- Fernyhough, C., & Fradley, E. (2005). Private speech on an executive task: Relations with task difficulty and task performance. *Cognitive Development, 20*(1), 103–120. <https://doi.org/10.1016/j.cogdev.2004.11.002>
- Feuerstein, R., Falik, L. H., Feuerstein, R. S., & Bohács, K. (2013). *A think-aloud and talk-aloud approach to building language: Overcoming disability, delay, and deficiency*. New York, NY: Teachers College, Columbia University.
- Feuerstein, R., Feuerstein, R. S., & Falik, L. H. (2009). *The Feuerstein instrumental enrichment basic program*. Israel: The Feuerstein Institute.
- Feuerstein, R., Feuerstein, R. S., Falik, L. H., & Rand, Y. (2002). *The dynamic assessment of cognitive modifiability: The Learning Propensity Assessment Device: Theory, instruments and techniques*. ICELP Publications. <https://psycnet.apa.org/record/2004-15007-000>
- Feuerstein, R., Feuerstein, R. S., Falik, L., & Rand, Y. (2006). *Creating and enhancing cognitive modifiability: The Feuerstein Instrumental Enrichment Program*. Jerusalem: The International Center for the Enhancement of Learning Potential.
- Feuerstein, R., & Feuerstein, S. (1991). Mediated learning experience: A theoretical review. In R. Feuerstein, P. S. Klein & A. J. Tannenbaum (Eds.), *Mediated learning experience (MLE): Theoretical, psychosocial and learning implications* (pp. 3–51). London, UK: Freund Publishing House.
- Fox, M. C., & Charness, N. (2010). How to gain eleven IQ points in ten minutes: Thinking aloud improves Raven's Matrices performance in older adults. *Aging, Neuropsychology, and Cognition, 17*, 191–204. <https://doi.org/10.1080/13825580903042668>
- Gillam, S. L., Fargo, J. D., & Robertson, K. S. C. (2009). Comprehension of expository text: Insights gained from think-aloud data. *American Journal of Speech-Language Pathology, 18*(1), 82–94. [https://doi.org/10.1044/1058-0360\(2008/07-0074\)](https://doi.org/10.1044/1058-0360(2008/07-0074))
- Goswami, U. (2001). Analogical reasoning in children. In D. Gentner, K. J. Holyoak & B. N. Kokinov (Eds.), *The analogical mind: Perspectives from cognitive science* (pp. 437–470). Cambridge, MA: MIT Press. <https://doi.org/10.7551/mitpress/1251.003.0018>
- Government of the Hong Kong Special Administrative Region (2019). *LCQ18: Support for children with special needs*. Retrieved from: <https://www.info.gov.hk/gia/general/202002/26/P2020022600486.htm>
- Haywood, H. C. (2013). What is cognitive education? The view from 30,000 feet. *Journal of Cognitive Education and Psychology, 12*(1), 26–44. <https://www.proquest.com/docview/1321095183?pq-origsite=gscholar&fromopenview=true>
- Hebbeler, K., Spiker, D., Bailey, D., Scarborough, A., Mallik, S., Simeonsson, R., & Singer, M. (2007). *Early intervention for infants & toddlers with disabilities and their families: participants, services, and outcomes*. Final report of the National Early Intervention Longitudinal Study (NEILS). Retrieved from https://www.sri.com/sites/default/files/publications/neils_finalreport_200702.pdf
- Heep Hong Society (2006). *Developmental assessment chart revised*. Hong Kong: Author.
- Hirai, A. H., Kogan, M. D., Kandasamy, V., Reuland, C., & Bethell, C. (2018). Prevalence and variation of developmental screening and surveillance in early childhood. *JAMA Pediatrics, 172*, 857–866. <https://doi.org/10.1001/jamapediatrics.2018.1524>
- Hong Kong Society for Child Health and Development (1987). *Manual of the reynell developmental language scales cantonese (Hong Kong version)*. Hong Kong: Author.

- Howie, D. (2015). The Feuerstein Approach in New Zealand: Building on the Past, for the Future. *Kairaranga*, 16(1), 37–44. <https://eric.ed.gov/?id=EJ1240552>
- Keung, Y. C., Ho, F. L., Kwan, P. S., & Shum, K. K. M. (2018). "Think Bright" higher-order thinking training program for preschoolers: Teacher's manual for individual training. Hong Kong: Heep Hong Society.
- Kang, E. K., Jeong, H. S., Moon, E. R., Lee, J. Y., & Lee, K. J. (2016). Cognitive and language function in aphasic patients assessed with the Korean version of mini-mental status examination. *Annals of Rehabilitation Medicine*, 40(1), 152. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4775749/>
- Kozubík, M., Síthová, S., Kajanová, A., & Rác, I. (2018). Is Feuerstein's Instrumental Enrichment (FIE) a good method for social inclusion of poor Slovak children in school? A study focused on social and educational levels. *Kontakt*, 20(1), e42–e47. <https://doi.org/10.1016/j.kontakt.2017.10.006>
- Kozulin, A., Lebeer, J., Madella-Noja, A., Gonzalez, F., Jeffrey, I., Rosenthal, N., & Koslowsky, M. (2010). Cognitive modifiability of children with developmental disabilities: A multicentre study using Feuerstein's Instrumental Enrichment—Basic Program. *Research in Developmental Disabilities*, 31(2), 551–559. <https://doi.org/10.1016/j.ridd.2009.12.001>
- Lam, M. Y. L., Lim, S. E., Ma, J. C., & Adams, L. (2003). What Hong Kong teachers and parents think about thinking. *Early Child Development and Care*, 173(1), 147–158. <https://doi.org/10.1080/0300443022000022495>
- Lebeer, J. (2014). Clinical and educational implications of Reuven Feuerstein's Mediated Learning Experience theory: current scientific evidence. *Transylvanian Journal of Psychology, Special Issue*, 3–8. <https://www.proquest.com/openview/1c9f8a7354817625074372d55d2bbc2a/1?pq-origsite=gscholar&cbl=2035941>
- Lebeer, J. (2016). Significance of the Feuerstein approach in neurocognitive rehabilitation. *NeuroRehabilitation*, 39(1), 19–35. <https://pubmed.ncbi.nlm.nih.gov/27341359/>
- Leung, C., Mak, R., Lau, V., Cheung, J., & Lam, C. (2013). The validation of a scale to measure cognitive development in Chinese preschool children. *Research in Developmental Disabilities*, 34, 2257–2267. <https://doi.org/10.1016/j.ridd.2013.04.003>
- Lidstone, J. S., Meins, E., & Fernyhough, C. (2012). Verbal mediation of cognition in children with specific language impairment. *Development and Psychopathology*, 24, 651–660. <https://doi.org/10.1017/S0954579412000223>
- Lidz, C. S. (2003). *Early childhood assessment*. New Jersey, NJ: John Wiley & Sons Inc.
- Lidz, C. S., & Haywood, H. C. (2014). From dynamic assessment to intervention: Can we get there from here. *Transylvanian Journal of Psychology, Special Issue*, 81–108. <https://www.proquest.com/openview/e8a88f3aa5211056ac2d60cdc6039527/1?pq-origsite=gscholar&cbl=2035941>
- McClintock, B., Pesco, D., & Martin-Chang, S. (2014). Thinking aloud: Effects on text comprehension by children with specific language impairment and their peers. *International Journal of Language & Communication Disorders*, 49, 637–648. <https://doi.org/10.1111/1460-6984.12081>
- McIntyre, K. (2017). Raising self-efficacy through ipsative assessment and Feuerstein's Instrumental Enrichment programme. In G. Hughes (Ed.), *Ipsative assessment and personal learning gain*. (pp. 85–104). London, UK: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-56502-0_5
- Molina, S., & Vived, E. (2004). Improvement of cognitive functions in children with Down syndrome through Bright Start program. *Journal of Cognitive Education and Psychology*, 4(1), 65–86. <https://doi.org/10.1891/194589504787382956>
- Murphy, R., & Maree, D. J. F. (2006). Meta-analysis of dynamic assessment research in South Africa. *Journal of Cognitive Education and Psychology*, 6(1), 32–60. <https://doi.org/10.1891/194589506787382279>
- Park, B., Korbach, A., & Brünken, R. (2020). Does thinking-aloud affect learning, visual information processing and cognitive load when learning with seductive details as expected from self-

- regulation perspective? *Computers in Human Behavior*, 111, 106411. <https://doi.org/10.1016/j.chb.2020.106411>
- Perna, R., & Loughan, A. R. (2013). Early developmental delays: A cross validation study. *Journal of Psychological Abnormalities in Children*, 1(2), 105. <https://doi.org/10.4172/2329-9525.1000105>
- Presseisen, B. Z., & Kozulin, A. (1992). Mediated learning - The contributions of Vygotsky and Feuerstein in theory and practice. <https://eric.ed.gov/?id=ED347202>
- Ricci, K., Assis, C. M. G., Nogueira, M. A. N., & Gotuzo, A. S. (2020). Feuerstein Instrumental Enrichment (FIE) basic in children with ADHD and Dyslexia/Programa de Enriquecimento Instrumental (PEI) basico em crianças com TDAH e Dislexia. *Psicologia Desde El Caribe*, 37(3), 259–283. <https://link.gale.com/apps/doc/A667878581/IFME?u=anon~ac3f5195&sid=googleScholar&xid=d96bb6e3>
- Ritchhart, R. D., & Perkins, D. N. (2004). Learning to think: the challenges of teaching thinking. In K. J. Holyoak & R. G. Morrison (Eds.), *The Cambridge handbook of thinking and reasoning* (pp. 775–802). Cambridge, MA: Cambridge University Press.
- Robson, S. (2006). *Developing thinking & understanding in young children. An Introduction for Students*. London, UK: Routledge. <https://doi.org/10.4324/9780203133354>
- Shevell, M., Majnemer, A., Platt, R. W., Webster, R., & Birnbaum, R. (2005). Developmental and functional outcomes at school age of preschool children with global developmental delay. *Journal of Child Neurology*, 20, 648–654. <https://doi.org/10.1177/08830738050200080301>
- Shevell, M. I., Majnemer, A., Rosenbaum, P., & Abrahamowicz, M. (2001). Etiologic determination of childhood developmental delay. *Brain and Development*, 23, 228–235. [https://doi.org/10.1016/S0387-7604\(01\)00212-1](https://doi.org/10.1016/S0387-7604(01)00212-1)
- Smith, M. (2006). *Mental retardation and developmental delay: Genetic and epigenetic factors*. New York, NY: Oxford University Press.
- Snow, R. E. (1991). Aptitude-treatment interaction as a framework for research on individual differences in psychotherapy. *Journal of Consulting and Clinical Psychology*, 59(2), 205. <https://doi.org/10.1037/0022-006X.59.2.205>
- Sönmez, Y., & Sulak, S. E. (2018). The effect of the thinking-aloud strategy on the reading comprehension skills of 4th grade primary school students. *Universal Journal of Educational Research*, 6(1), 168–172. <https://eric.ed.gov/?id=EJ1165440>
- Sternberg, R. J. (2014). The current status of the theory of structural cognitive modifiability in relation to theories of intelligence. *Transylvanian Journal of Psychology, Special Issue*, 9–13. <https://www.proquest.com/openview/80ac68040d7e87a9a8bf50059206e632/1?pq-origsite=gscholar&cbl=2035941>
- Todor, O. (2015). Research on the usefulness of Feuerstein method in educating the sociability of children aged between 3 and 7 (preschool children). *Procedia-Social and Behavioral Sciences*, 180, 1692–1697. <https://doi.org/10.1016/j.sbspro.2015.05.071>
- Tzuriel, D. (2021). *Mediated learning and cognitive modifiability*. New York, NY: Springer.
- Tzuriel, D., Cohen, S., Feuerstein, R., Devisheim, H., Zaguri-Vittenberg, S., Goldenberg, R., . . . Cagan, A. (2021). Evaluation of the Feuerstein Instrumental Enrichment (FIE) program among Israeli-Arab students. *International Journal of School & Educational Psychology*, 1–16. <https://doi.org/10.1080/21683603.2021.1951409>. Online ahead of print.
- Tzuriel, D., & Galinka, E. (2000). *The children's conceptual and perceptual analogies modifiability (CCPAM) test: Instruction manual*. Ramat Gan, Israel: School of Education, Bar-Ilan University.
- Tzuriel, D., & Hanuka-Levy, D. (2014). Siblings' mediated learning strategies in families with and without children with intellectual disabilities. *American Journal on Intellectual and Developmental Disabilities*, 119, 565–588. <https://doi.org/10.1352/1944-7558-119.6.565>
- Tzuriel, D., Kaniell, S., Kanner, A., & Haywood, H. C. (1999). Effects of the Bright Start program in kindergarten on transfer and academic achievement. *Early Childhood Research Quarterly*, 14(1), 111–141. [https://doi.org/10.1016/S0885-2006\(99\)80009-X](https://doi.org/10.1016/S0885-2006(99)80009-X)

- Tzuriel, D., Kaniel, S., Zeliger, M., Friedman, A., & Haywood, H. C. (1998). Effects of the Bright Start program in kindergarten on use of mediation and children's cognitive modifiability. *Child Development and Care*, 143, 1–20. <https://doi.org/10.1080/0300443981430101>
- Tzuriel, D., & Klein, P. S. (1985). The assessment of analogical thinking modifiability in disadvantaged, regular, special education, and mentally retarded children. *Journal of Abnormal Child Psychology*, 13, 539–552. <https://doi.org/10.1007/BF00923140>
- Tzuriel, D., & Klein, P. S. (1990). *The children's analogical thinking modifiability test: Instruction manual*. Ramat Gan, Israel: School of Education, Bar-Ilan University.
- Tzuriel, D., & Remer, R. (2018). Mediation with a puppet: The effects on teachers' mediated learning strategies with children in special education and regular kindergartens. *Learning and Instruction*, 58, 295–304. <https://doi.org/10.1016/j.learninstruc.2018.08.001>
- Tzuriel, D., & Samuels, M. T. (2000). Dynamic assessment of learning potential: Inter-rater reliability of deficient cognitive functions, types of mediation, and non-intellective factors. *Journal of Cognitive Education and Psychology*, 1(1), 40–64. <https://doi.org/10.1891/1945-8959.1.1.40>
- Tzuriel, D., & Shomron, V. (2018). The effects of mother-child mediated learning strategies on psychological resilience and cognitive modifiability of boys with learning disability. *British Journal of Educational Psychology*, 88(2), 236–260. <https://doi.org/10.1111/bjep.12219>
- Vedovelli, C. (2014). Neuro-teaching in Primary School. The principles of Feuerstein's mediated learning integrated into school curriculum. *Transylvanian Journal of Psychology*, 195–218. <https://www.proquest.com/openview/eba88f3aa521105601da88957ba7e277/1/index>
- Vygotsky, L. (1978). Interaction between learning and development. *Readings on the Development of Children*, 23(3), 34–41.
- Vygotsky, L. S. (2012). *Thought and language*. Cambridge, MA: MIT Press.
- Wechsler, D. (2000). *The wechsler preschool and primary scale of intelligence - revised*. San Antonio, TX: The Psychological Corporation.
- Wechsler, D. (2012). *Wechsler preschool and primary scale of intelligence—fourth edition technical manual and interpretive manual*. San Antonio, TX: Psychological Corporation.
- Winsler, A. E., Fernyhough, C. E., & Montero, I. E. (2009). *Private speech, executive functioning, and the development of verbal self-regulation*. Cambridge, UK: Cambridge University Press.
- Wong, A. M. Y., Leung, C., Siu, E. K. L., & Lam, C. (2012). Validating the language domain subtest in a developmental assessment scale for preschool children. *Research in Developmental Disabilities*, 33, 1633–1641. <https://doi.org/10.1016/j.ridd.2012.03.002>

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