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Does off-campus training encourage numeracy skills and social-emotional skills? Evidence from China

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ABSTRACT

The governance of off-campus training has emerged as a prominent topic of research; however, its exploration in the context of preschool education remains relatively limited. This study addresses this gap by investigating the impact of off-campus training participation on the development of 644 preschoolers selected from 17 kindergartens in Beijing. Results derived from propensity score matching analysis reveal that the influence of participation on the early numeracy and socioemotional skills development of preschoolers was generally nonsignificant. Further subsample analysis indicates that engagement in off-campus sports training notably enhances preschoolers' early numeracy skills, whereas participation in other forms of off-campus training exhibits no significant impact. Ultimately, this study makes recommendations for scientific childcare from the government, kindergartens and parents.

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Preschool children; off-campus training; numeracy skills; social-emotional skills; propensity score matching; China

I. Introduction

Renowned economist James J. Heckman, recipient of the Nobel Prize, introduced the concept of the law of return on investment in human capital, emphasizing a life-cycle perspective. He found that early investments in human capital for disadvantaged children yield the highest economic returns, with the timeliness of investment correlating with greater financial benefits. Research indicates that cognitive, social, and emotional competencies acquired during early childhood significantly influence future learning effectiveness (Heckman et al., 2010). Early investments in human capital facilitate the development of cognitive and social-emotional skills in children, leading to extended educational attainment, reduced crime rates, enhanced employability, and other positive outcomes (James & Scott, 2019). Given the critical role of education, including in terms of potential investment in human capital, it is imperative to examine all areas of a young child's educational experience. This includes off-campus training, which may encompass various tutoring and training activities aimed at improving academic performance, expanding knowledge and skills, and developing interests and specialties. The off-campus training includes activities for different school periods (preschool and school age) and also different types of activities (sports, arts, culture, etc.). As such, the question of whether off-campus training contributes to the development of preschool children is a growing area of focus and concern.

According to the 2017 White Paper on Education Consumption in Chinese Families released by Sina Education and the Sina Data Center, based on a questionnaire survey of over 50,000 parents across China, it was found that 89.92% of preschool-aged children have participated in off-

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campus training, with hobbies and interests accounting for 58.73% of such training. Additionally, in 43.06% of surveyed families, off-campus training accounted for the largest portion of education consumption. Among families that do not enrol their children in off-campus training, 27.27% cited financial constraints. Notably, 80% of preschoolers spend over $2,000 annually on off-campus training, with nearly 50% spending more than $5,000. This underscores the substantial participation of preschool children in off-campus training and the significant proportion of education expenses attributed to it, placing a considerable burden on both preschool children and their families.

Preschool years are crucial for the development of children's mathematical abilities and social-emotional skills. Proficiency in mathematics during the preschool years is a strong predictor of academic achievement in mathematical throughout elementary school and beyond (Koponen et al., 2007). Furthermore, social-emotional skills assist children in adapting to new environments, fostering supportive relationships with peers and adults, and enhancing their participation in learning activities (Wu & Li, 2023). The social-emotional capabilities of preschoolers are a reliable predictor of their future academic performance, social adjustment, mental health status, and, ultimately, socioeconomic success (Wu & Li, 2023).

II. Review of literature

The definition of off-campus training lacks clarity, with researchers both domestically and internationally referring to it by various terms such as 'shadow education' (Mark & Qin, 2012; Xue, 2015), 'extracurricular tutoring' (Q. Zhang et al., 2023; K. Zhang, Liu, et al., 2024b), or 'after-school tutoring' (Shi et al., 2022a; Shi et al., 2023). In the context of this study, 'off-campus training' does not denote a specific geographic location but rather refers to training services outside the formal education provided by kindergartens. Preschool-age children may receive such training either within or outside of kindergarten settings. Broadly, off-campus training falls into two main categories: subject-focused tuition aimed at preparing for future elementary school examinations and interest-based training aimed at fostering the development of hobbies, specialties, and overall skill development (Huang, 2018).

Research findings concerning the impact of off-campus training participation on school-age children's mathematical abilities are characterized by inconsistency (Wang, 2020; Y. Zhang et al., 2021, 2024) Furthermore, there exists a divergence in the observed positive effects (Europäischer Sozialfonds (ESF) et al., 2011; Wang, 2020) and negative effects (Bray, 2003) of off-campus training participation on children's mathematical abilities. Research on the impact of off-campus training participation on children's social-emotional skills has predominantly focused on the interplay between negative emotions (Dui & Li, 2021; Li & Liu, 2022) and positive emotions (Sun & Tang, 2019). The existence of two opposing conclusions about the impact of off-campus training on school-age children suggests that such opposing conclusions may also exist at the preschool level. Research findings on the effects of participation in off-campus training on the development of preschoolers' mathematical skills and socioemotional competence have yielded inconsistent results. A study conducted among preschoolers from middle-class families in China revealed a positive association between the extent of off-campus training participation and preschoolers' mathematical as well as social skills. Factors such as lower family socioeconomic status, deficient home-learning environments, and greater need for compensatory measures have been identified (Ren et al., 2021a). Conversely, participation in off-campus training has been linked to enhanced mathematical skills but not necessarily improved social skills among preschoolers from lower socioeconomic backgrounds (Ren & Zhang, 2020). First, off-campus training participation has been found to be related to preschooler's mathematical development. Research suggests a significant positive correlation between off-campus training participation and the quality of preschoolers' learning experiences. Notably, studies indicate that participation in sports-based and music-based off-campus training confers advantages on children's mathematical

abilities (Covay & Carbonaro, 2010). In a subsequent survey conducted among urban Chinese children, it was observed that broader and more intensive off-campus training participation correlated with enhanced early mathematical skills among preschoolers (Ren et al., 2021b).

Secondly, off-campus training participation has been found to be related to preschoolers' social-emotional capabilities. Both early education classes prior to kindergarten enrolment and interest-based off-campus training post-kindergarten entry were found to significantly impact preschoolers' social emotions (Shi & Liu, 2019). However, some studies have reached contrasting conclusions, suggesting that participation off-campus training participation is not associated with social-emotional development in preschoolers (Shi et al., 2022a; Shi et al., 2022b). After controlling for demographic variables and children's prior performance, extracurricular involvement was not associated with children's social-emotional development. In a recent study, Ren's research examined the linear and nonlinear impact of off-campus training on three domains of development among Chinese preschoolers, and the results show that the intensity, breadth, and total number of participants in off-campus training were identified as having quadratic effects on the social-emotional development of the participating preschoolers (Ren et al., 2020).

(iv). The current study

Upon synthesizing existing literature, several notable shortcomings were identified. First, a substantial portion of research has focused on investigating the impact of children's participation in off-campus training on their cognitive and non-cognitive abilities during compulsory education. Nonetheless, a glaring gap exists in research pertaining to the impact of off-campus training on the cognitive and non-cognitive abilities of preschool children. Second, while existing studies have examined the influence of off-campus training on child development, they lack detailed categorization and fail to classify off-campus training into distinct types such as sports, arts, cultural activities, mental development, parenting, and early childhood classes. Therefore, this deficiency hinders the ability to provide comprehensive guidance to parents regarding their choices concerning off-campus training participation. Third, most existing studies use rely on ordinary linear regression analysis, which is susceptible to endogeneity issues, and may lead to biased conclusions.

The question of whether participation in off-campus training is conducive to the development of preschool children has increasingly become a matter of concern and has even resulted in parents experiencing anxiety (Ding et al., 2022; Yu & Yao, 2022). Studies have yielded inconsistent findings regarding the effects of such participation on preschoolers' mathematical skills and social-emotional skills. Existing research methodologies are often unable to disentangle mixed factors beyond off-campus training participation, thereby limiting conclusive insights. To address this gap, this study employs Propensity Score Matching to ascertain the impact of off-campus training participation on preschool children's mathematical and social-emotional skills. By exploring the specific effects of various types of off-campus training — including sports, arts, mental training, early childhood classes, and parent–child classes — on preschoolers' development. This study aims to provide actionable policy recommendations for the management of off-campus training and the holistic development of preschool children.

Therefore, based on the limitations of existing studies and a need to invest in quality early childhood education and care, this study proposes the following hypotheses:

Hypothesis 1: Participation in off-campus training affects preschool children's mathematical skill and social-emotional skills.

Hypothesis 2: Participation in different types of off-campus training affects preschool children's mathematical skill and social-emotional skills.

III. Data and research methodology

(i). Sources of data

The data for this study were obtained during 2023 from a university in Beijing, where the researchers were based in a School of Preschool Education Program on Assessing Preschoolers' Learning and Development. The focus was on kindergarten settings; in China, a kindergarten is an institution that provides education for children aged 3–6 years old; preschoolers are young children between the age of 0–6 years old, and kindergarteners are young children between the ages of 3 and 6 years old.

The project conducted surveys among children and parents from 17 kindergartens in a district of Beijing, resulting in a total of 685 questionnaires collected. As only 644 preschoolers completed the 'Social-emotional skills' test, the remaining 41 preschoolers did not complete the 'Social-emotional skills' test. In order to ensure accuracy of results, we excluded these 41 questionnaires. Ultimately, the population of this study was 644 preschoolers. After excluding invalid responses, a questionnaire validity rate of 94.01% was established. At the individual level, the sample consisted of 51% boys, with 52% representing only children. In terms of kindergarten type, 59% of participating children were enrolled at public kindergartens. Family demographics revealed that the average highest parental education level was a college degree, the highest parental occupation averaged at the middle level, and the average monthly family income exceeded 15,000RMB, which exceeds middle-income level (Chang & Li, 2012). Educational expectations (i.e. What is the minimum level of education parents want their children to complete?) indicated a preference for a bachelor's degree or higher. These statistics affirm the sample's robust representation.

(ii). Variable descriptions

1. Explained variables

The explanatory variables in this study encompassed early numeracy and social-emotional skills derived from International Development and Early Learning Assessments (IDELA). IDELA, developed by staff from the Children's Aid Society of America's Monitoring and Evaluation Department in collaboration with experts from the Early Childhood Education and Development Program, serves as a direct assessment tool for evaluating children's early learning and development. Since its inception, IDELA has been validated in over 103 countries, demonstrating robust reliability (IDELA, 2025).

The assessment process involved one-on-one measurements of preschoolers, with scores recorded based on their behaviour. Trained assessors conducted these assessments in familiar and quiet activity rooms, ensuring an environment which was best conducive to the research process. The assessors played games and engaged in activities with preschoolers. They showed preschoolers different games with stories, pictures, numbers, and other things such as sticks, stones, beads. The assessment duration averaged approximately 8–10 minutes.

The Numeracy Skills assessment comprised 23 test questions across seven indicators, including comparing size and length, sorting and categorizing, shape recognition, number recognition, one-to-one correspondence, simple addition and subtraction, and completing puzzles. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.762. An example is provided here for a clearer understanding of the measurement tool on Numeracy Skills. See Figure 1 for a specific example about measurements on addition and subtraction (emergent numeracy).

The Social-emotional skills assessment encompassed 16 test questions across five indicators: personal awareness, peer relationships, emotional awareness, empathy/transfer, and conflict resolution. The KMO measure was 0.762. An example is provided here for a clearer understanding of the measurement tool on Social-emotional skills. See Figure 2 for a specific example about measurements on self-awareness (social-emotional).

ITEM 7. ADDITION AND SUBTRACTION (EMERGENT NUMERACY)

Materials: Beans used in previous item and picture cards with bikes /apples

I have another game with beans. Here I have 3 beans.

Lay out 3 beans

Now my friend gives me 2 more beans.

Lay these out near the first objects but leaving a little space between the two groups.

How many beans do I have in total?

Wait for the child to count and score response. Then show the picture with the bikes and say

Let's try another one. Here are 2 bikes, if you put 2 more bikes in the picture how many would there be?

Ok. Now I have another picture. Here are 3 apples. If you took one away how many apples would be left?

SCORING

	Correct	Incorrect/ Do not know	Refused/ Skipped
b) Child adds 3 and 2	1	0	999
c) Child adds 2 and 2	1	0	999
c) Child subtracts 1 from 3	1	0	999

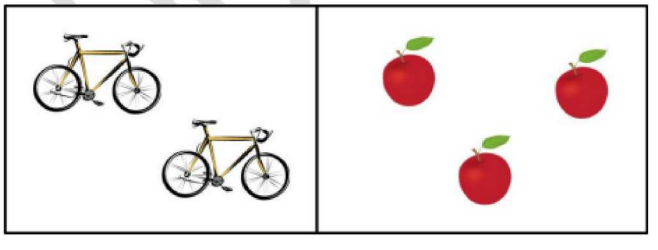

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Figure 1. Examples of mathematical skills measurement tools.

In conclusion, both the numeracy and social-emotional skills scales exhibited strong reliability.

2. Explanatory variables

The primary explanatory variable in this study is based on the questionnaire item: 'Your children have attended or are currently attending off-campus training programs (only counting those that lasted more than 3 months).'

- **Sports-type off-campus training** encompasses activities such as tennis, table tennis, basketball, wushu, taekwondo, and judo. Participation is scored as 1 point, while non-participation receives 0 points.
- **Arts type of off-campus training** includes disciplines like dance, painting, piano, and other musical instruments, such as singing, recitation, acting, and hosting. Participation is scored as 1 point, with non-participation receiving 0 points.

ITEM 1. SELF-AWARENESS (SOCIAL-EMOTIONAL)

Materials: None

It is very nice to meet you <child name>. I am going to ask you some questions about yourself now. Please answer them if you can, but do not worry if you do not know all of the answers.

Ask the child the following questions one at a time.

SCORING

	Correct	Incorrect/ Do not know	Refused/ Skipped
a) Please tell me your first and last name	1	0	999
b) Please tell me how old you are	1	0	999
c) Are you a boy or a girl?	1	0	999
d) Please tell me the name of one person who takes care of you at home	1	0	999
e) Please tell me the name of the neighborhood/community/village that you live in	1	0	999
f) Please tell me the name of the state/country that you live in	1	0	999

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Figure 2. Examples of social-emotional skills measurement tools.

- **Mind development type of off-campus training** comprises activities like beadwork, Rubik's Cube, and right brain development exercises. Participation was scored as 1 point, with non-participation receiving 0 points.
- **Cultural types of off-campus training** included pursuits like chess, calligraphy, and English. Participation was scored as 1 point, with non-participation receiving 0 points.
- **Early childhood classes** refer to off-campus training classes tailored for infants and toddlers aged 0–3 years old. Participation is credited with 1 point, while non-participation is scored as 0 points.
- **Parent–child classes** are defined as off-campus training classes involving parental participation, targeting children aged 3–6 years old; participation is credited as 1 point, and non-participation as 0 points.
- **Off-campus training is a combination of six variables**: sports-type, arts-type, mind-development-type, culture-type, early childhood classes, and parent–child classes. Each form of participation earns 1 point, while non-participation is assigned zero points.

3. Control variables

Participation in off-campus training is influenced by various factors, including individual characteristics, school quality, family socioeconomic background, and geographical location (Xue, 2016). To control for these influences, this study selected several factors affecting both the explanatory and explained variables, encompassing individual, family, and kindergarten levels. At the individual level, sex, age, and whether the child is an only child were chosen as control variables. At the family level, control variables included the highest parental education level, highest parental occupational stratification, monthly family income, urban/rural status, educational expectations, and

family parenting environment. The choice of whether the kindergarten was public served as the control variable at the kindergarten level.

Parental Highest Occupational Stratification Drawing was categorized into lower, middle, and upper tiers based on Li's Occupational Stratification Study (Li, 2005). This classification utilized the 'current father's occupation' and 'current mother's occupation' from the questionnaire, selecting the highest occupational stratum of either parent.

The family parenting environment was assessed utilizing the Family Parenting Environment Scale for Urban 3–6-Year-Olds developed by He Shousen (He et al., 2009). This scale comprises 53 items and demonstrates strong homogeneous reliability, with a Cronbach's alpha coefficient of 0.930, a split-half reliability of 0.871, and a retest reliability coefficient of 0.707. The scale exhibits good content and structural validity. Specific descriptions of the variables are provided in Table 1.

(iii). Data analysis methods – propensity score matching

Propensity score matching (PSM) is frequently employed to evaluate the effects of programmes or policies post-implementation. This quasi-experimental approach utilizes observable matching variables to pair observations in the treatment and control groups with similar values, thereby addressing data imbalances in the two groups of observable variables and mitigating significant bias. This

Table 1. Description of variables.

		Variable name	Variable description
Explanatory variables		Whether participated in off-campus training	no = 0; yes = 1
		Whether participated in early childhood class	no = 0; yes = 1
		Whether participated in parent–child class	no = 0; yes = 1
		Whether participated in sports-type off-campus training	no = 0; yes = 1
		Whether participated in arts-type off-campus training	no = 0; yes = 1
		Whether participated in culture-type off-campus training	no = 0; yes = 1
		Whether participated in mind development-type off-campus training	no = 0; yes = 1
Explained variables		Numeracy Skills	Continuous variable
		Social-Emotional Skills	Continuous variable
	The individual level	Age	Continuous variable
		Sex	girl = 0; boy = 1
		Only child or not	no = 0; yes = 1
	The kindergarten level	Whether public kindergarten	no = 0; yes = 1
Control variables	The family level	The highest parental education	Take the variable with the parent highest in educational attainment, this variable is a rank variable, the value of the variable: less than college = 1; three-year college = 2; bachelor's degree = 3; master's degree and above = 4
		The highest parental occupational stratification	Take the variable with the parent's highest occupational level as the value, this variable is a rank variable, the value of the variable: lower lever = 1; middle lever = 2; upper lever = 3
		Monthly family income	8000 RMB and below = 1; 8001-15000 RMB = 2; 15001-20000 RMB = 3; above RMB 20001 = 4
		Urban/Rural	rural = 0; urban = 1
		Educational expectations	bachelor's degree and below = 1; master's degree and above = 2
		Family parenting environment	Continuous variable

study aimed to identify a counterfactual control group (preschoolers who did not participate in off-campus training) for the treatment group (preschoolers who participated in off-campus training) that closely resembles all aspects of the control variables.

Traditional ordinary least squares (OLS) methods based on the assumption of random assignment increase the probability of sample selection and bias in counterfactual estimation. Therefore, PSM was employed to simulate treatment effects in a counterfactual scenario, enabling the assessment of participation in off-campus training on preschoolers' numeracy and social-emotional skills.

The specific analytical steps of PSM in this study included estimating the propensity score, implementing the match, diagnosing the match, and conducting post-matching analysis (Huang & Fan, 2022). First, propensity scores were calculated by constructing a logit model to simulate individual behavioural choices and estimate the probability of receiving the intervention. Second, matching was performed utilizing the Mahalanobis metric distance matching method, leveraging propensity scores to pair individuals in treatment and control groups with similar scores. Third, match diagnoses were conducted to evaluate data balance and assess common support intervals post-matching. Finally, a post-matching analysis compared differences in numeracy and social-emotional skills between preschoolers who participated in off-campus training and those who did not. Therefore, for the Average Treatment Effect of the treated group (ATT), the model expression is.

$$ATT = E\{E[Yi1|Di = 1, p(X)] - E[Yi0|Di = 1, p(X)]\}$$

In the above model, Yi1 represents the numeracy and social-emotional skills of preschoolers who participated in the off-campus training. Yi0 represents the numeracy and social-emotional skills of preschoolers who did not participate in the off-campus training. Di is a dichotomous variable labelled $Di = 1$ if the preschooler is involved in off-campus training and $Di = 0$ if the preschooler is not involved. p(X) is the probability of participating in off-campus training after controlling for preschoolers' individual-, kindergarten-, and family-level factors.

This study specifically utilizes the Mahalanobis metric distance matching. Mahalanobis metric distance matching is a mathematical method utilized to measure the covariance distance between data points independent of changes in the unit of measurement concerning the object of measurement with scale-invariant characteristics. The matching step of the Mahalanobis distance is as follows: first, the matching order of the processor individuals is arranged according to the randomization, and then the Mahalanobis distance between the first ranked individual of the processing group and the individual of the control group in which it is located is calculated, from which the individual of the control group with the smallest Mahalanobis distance is paired up. The process is repeated in such a way that a match is eventually found for all individuals in the treatment group, forming a new sample.

To ensure the robustness of the estimation results, this study simultaneously estimated the effect of off-campus training participation on preschoolers' numeracy and social-emotional skills utilizing the nearest-neighbour matching (1:2), the radius matching (with a radius of 0.01), the kernel matching, and the local linear regression matching.

IV. Results of the empirical analysis

(i). Analysis of differences in participation in off-campus training on key variables

1. Descriptive statistics and pre-matching equilibrium tests

In this study, to test whether there is a significant difference between the pre-matching treatment group and the control group in terms of the explanatory and control variables, the t-test was utilized to test for differences in the relevant variables. The findings exhibited a significant difference between the treatment and control groups for all types of off-campus training and all control and explanatory variables. This indicates significant imbalance and multicollinearity between the explanatory variables and each variable of interest before pairing. It is, therefore, necessary to

pair the original data to estimate the 'net effects' of the explanatory variables on the elucidated variables.

2. Propensity index estimation: logit models

We incorporated each of the confounding variables and their binomials into a logit model to predict the probability of a preschooler participating in each type of off-campus training. The findings of the regression models are presented in Table 2, exhibiting that a portion of the variables significantly affected the propensity of preschoolers' off-campus training participation.

By analyzing the results of the above data, it becomes apparent that selectivity plays a pivotal role in determining participation in various forms of off-campus training, including early childhood classes, parent–child classes, sports-type off-campus training, arts-type off-campus training, culture-type off-campus training, and mind-development-type off-campus training. Put differently, certain confounding variables significantly influenced individuals' decisions regarding participation in off-campus training. Consequently, the implementation of PSM was deemed necessary to mitigate the confounding variables in the study results.

(ii). Impact of participation in off-campus training on preschoolers' numeracy skills and social-emotional skills

1. Data balance test

In this study, the standardized mean deviation of the control variables for the preschoolers in the paired group was less than 10% after utilizing the Mahalanobis metric distance matching method. None of the control variables differed significantly between the treatment and control groups. In the t-tests, the differences between the groups were significant at the 1% level, with *p*-values greater than 0.01. As exhibited in Figure 3, a large overlapping portion of the control and treatment groups was evident after pairing for off-campus training participation, with a large common support interval for each paired group. Therefore, the common support assumption was satisfied, and the data were well-balanced after pairing. The same findings were exhibited when participating in all types of off-campus training with robust data results after pairing (See Appendix 1 for density plots of propensity values before and after pairing for the other groups).

2. Approximate causality and effect sizes

The control group was paired with the treatment group utilizing the Mahalanobis distance matching method, and the mean treatment effect of ATT was calculated for the treatment group based on the corresponding propensity scores of the preschoolers involved in the pairing (Table 3).

As exhibited in Table 3, the effects of participation in different types of off-campus training on preschoolers' numeracy and social-emotional skills were inconsistent after controlling for preschoolers' individual, family, and kindergarten levels. Specifically, participation in early childhood classes and sports-based off-campus training had significant positive effects on preschoolers' Numeracy Skills (all significant at the 10% level). The average treatment effect of ATT values were 1.19, 1.08, and 0.96, respectively. Participation in sports – and arts-type off-campus training had a significant positive effect on the Social-Emotional Skills of preschoolers (both significant at the 10% level). The average treatment effect of ATT values was 0.85 and 0.66, respectively. In contrast, participation in off-campus training, parent–child classes, culture-type off-campus training, and mind-development-type off-campus training did not have a significant effect on the numeracy skills and social-emotional skills of preschoolers.

Bootstrap self-sampling (which was repeated 500 times) was utilized to test the significance and standard error of the estimated effects to improve estimation precision. From the results of the two adjusted columns of Table 3, it was found that participation in early childhood classes had a

Table 2. Logit model estimation for participation in off-campus training.

	Whether Participated in Off-Campus Training	Whether Participated in Early Childhood Class	Whether Participated in Parent–Child Class	Whether Participated in Sports-Type Off-Campus Training	Whether Participated in Arts-Type Off-Campus Training	Whether Participated in Culture-Type Off-Campus Training	Whether Participated in Mind Development-Type Off-Campus Training
Age	0.82**	0.15	6.72*	0.32	0.58**	5.77**	0.17
	(0.28)	(0.16)	(2.93)	(0.22)	(0.23)	(2.67)	(0.18)
Sex	0.07	7.52***	0.10	0.52	−1.49***	4.35**	4.18*
	(0.65)	(2.06)	(0.31)	(0.71)	(0.20)	(2.08)	(2.24)
Whether Public Kindergarten	0.04	0.46	0.39	−0.36*	−0.68***	4.10***	1.29
	(0.55)	(0.29)	(0.33)	(0.19)	(0.20)	(1.54)	(1.06)
The Highest Parental Education	0.27*	2.46*	−0.36	−0.12	0.96*	−1.65**	0.50
	(0.14)	(1.27)	(0.23)	(0.82)	(0.56)	(0.78)	(0.47)
Monthly Family Income	0.74***	0.37	4.00*	−0.07	0.59***	2.78***	3.17***
	(0.17)	(0.52)	(1.65)	(0.76)	(0.11)	(0.65)	(0.91)
The Highest Parental Occupational Stratification	0.32	−4.27**	−6.37**	1.81***	1.43**	1.24***	4.17**
	(0.20)	(1.81)	(2.29)	(0.68)	(0.61)	(0.36)	(1.96)
Educational Expectations	3.52***	0.54**	0.82	0.73 ***	−1.00	5.30*	3.50**
	(0.96)	(0.20)	(0.55)	(0.29)	(0.81)	(2.80)	(1.42)
Urban/Rural	0.12	−0.02	48.66**	−0.35	0.41	2.01*	2.27**
	(0.27)	(0.30)	(22.36)	(0.28)	(0.28)	(1.04)	(1.07)
Only Child or not	0.74**	1.32	−17.67	3.09*	5.25***	−1.61	−0.07
	(0.27)	(1.68)	(1598.82)	(1.66)	(1.83)	(2.67)	(0.24)
Family Parenting Environment	0.50	0.15**	−0.03	−0.01	0	0.04***	0.07**
	(0.31)	(0.06)	(0.02)	(0)	(0)	(0.01)	(0.03)

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; ()standard error.

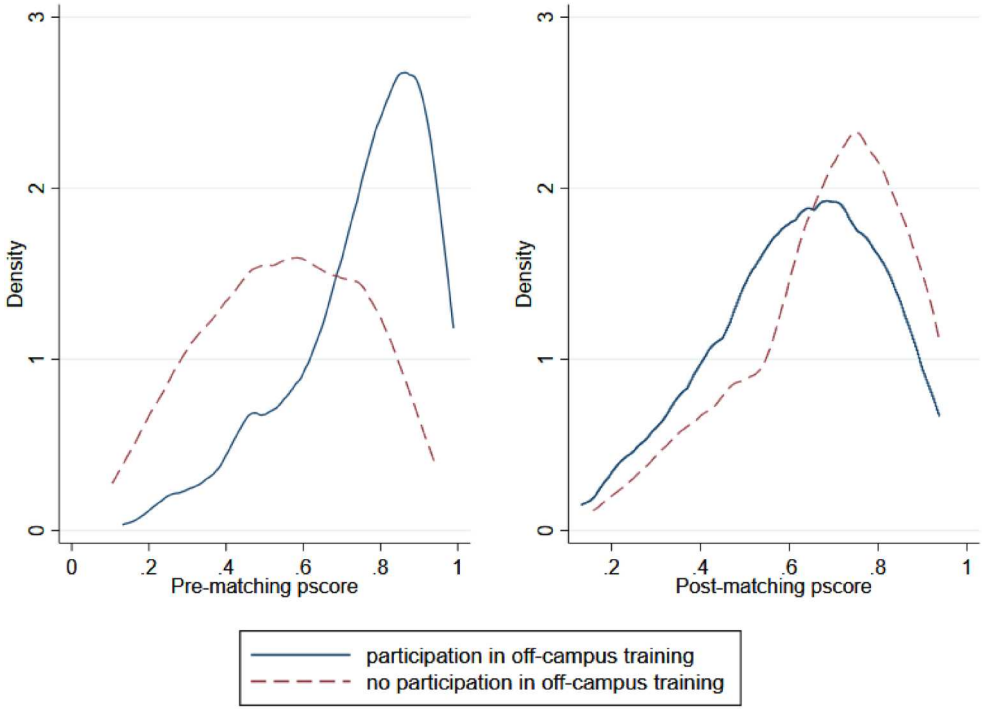

Figure 3. Changes in the distribution of propensity scores before and after matching on whether or not to participate in off-campus training.

significant positive effect on preschoolers' numeracy skills; participation in sports-type off-campus training had a significant positive effect on both numeracy skills and social-emotional skills, whereas participation in other types of off-campus training had a non-significant effect on preschoolers' numeracy skills and social-emotional skills.

3. Robustness test

In order to verify the robustness of the estimation results of the Marginal Distance Matching above, this study utilized Near Neighbour Matching (1:2), Radius Matching (radius of 0.01), Kernel Matching, and Local Linear Regression Matching to test the robustness of the average effect of the treatment group. The results are presented in Table 4.

The results in Table 4 exhibit that participation in sports-based off-campus training has a significantly positive effect on preschoolers' Numeracy Skills, with robust findings being exhibited. The effects of participation in off-campus training, parent–child classes, and arts-type off-campus training on preschoolers' numeracy and social-emotional skills were nonsignificant, and the findings were robust.

V. Main conclusions

This study investigated the impact of off-campus training participation on preschool children's development. Although prior studies have explored the impact of off-campus training participation on children's development, they have not clearly distinguished between the impact of various types of off-campus training on preschool children's development nor analyzed the impact of participation in various types of off-campus training on social-emotional and numeracy skills. This study, therefore, investigated the effects of participating in different types of off-

Table 3. Results of ATT.

				Pre-adjustment		Post-adjustment	
	(Unmatched)/(Matched)	Treatment group	Control group	ATT	t	ATT	*P*
Whether participated in off-campus training							
Numeracy Skills	*U*	42.74	40.71	2.04***	4.1		
	M	42.59	41.81	0.78	1	0.78	0.29
Social-Emotional Skills	*U*	15.56	15.08	0.48*	1.53		
	M	15.40	15.21	0.20	0.37	0.20	0.68
Whether participated in early childhood class							
Numeracy Skills	*U*	43.22	41.71	1.52***	2.88		
	M	43.43	42.24	1.19*	1.76	1.19*	0.08
Social-Emotional Skills	*U*	15.20	15.48	−0.28	−0.85		
	M	15.25	15.40	−0.15	−0.31	−0.15	0.77
Whether participated in parent–child class							
Numeracy Skills	*U*	42.49	42.07	0.42	0.48		
	M	42.42	42.80	−0.38	0.3	−0.38	0.78
Social-Emotional Skills	*U*	15.24	15.42	−0.19	0.35		
	M	15.00	15.33	−0.33	0.43	−0.33	0.74
Whether participated in sports-type off-campus training							
Numeracy Skills	*U*	43.36	41.58	1.78***	3.52		
	M	43.42	42.34	1.08*	1.61	1.08*	0.09
Social-Emotional Skills	*U*	15.61	15.32	0.29	0.90		
	M	15.59	14.73	0.85*	1.87	0.85*	0.09
Whether participated in arts-type off-campus training							
Numeracy Skills	*U*	43.24	41.07	2.17***	4.73		
	M	43.19	42.48	0.71	0.93	0.71	0.25
Social-Emotional Skills	*U*	15.91	14.95	0.96***	3.37		
	M	15.82	15.16	0.66*	1.40	0.66	0.11
Whether participated in culture-type off-campus training							
Numeracy Skills	*U*	43.54	41.66	1.87***	3.45		
	M	43.47	43.01	0.46	0.68	0.46	0.48
Social-Emotional Skills	*U*	15.33	15.43	−0.10	0.31		
	M	15.25	15.61	−0.36	0.68	−0.36	0.49
Whether participated in mind development-type off-campus training							
Numeracy Skills	*U*	43.54	41.86	1.69***	2.59		
	M	43.68	42.94	0.74	0.97	0.74	0.37
Social-Emotional Skills	*U*	15.63	15.37	0.26	0.63		
	M	15.75	15.03	0.71	1.25	0.71	0.28

*$p < 0.1$;**$p < 0.05$;***$p < 0.01$.

campus training on preschoolers' development of numeracy and social-emotional skills utilizing the PSM method with 644 preschoolers from 17 kindergartens in Beijing, China. The model diagram presents in Figure 4 is more clearly. Participation in off-campus training is influenced by three factors: at the individual level, at the family level, and at the kindergarten level. The PSM approach is to eliminate the differences between these three factors in order to find the pure utility of X over Y (X is whether participated in off-campus training. Y is child development.). Two important conclusions were obtained.

First, the effects of off-campus training participation on the preschoolers' numeracy and social-emotional skills were not significant. Second, the sub-sample analysis exhibited that participation in sports-based off-campus training had a significant positive effect on preschoolers' numeracy skills, as well as some positive (but not significant) effects on social-emotional skills. Participation in arts-type off-campus training, early childhood classes, and parent–child classes also had a non-significant influence on preschoolers' numeracy and social-emotional skills. In addition, participation in mind development-type and culture-type off-campus training had minimal effect on preschoolers' numeracy and social-emotional skills and was mostly nonsignificant. All the above findings are generally robust.

Table 4. Robustness test.

	Whether participated in off-campus training							
	Nearest-neighbour matching (1:2)		Radius matching (with a radius of 0.01)		Kernel matching		Local linear regression matching.	
	ATT	t	ATT	t	ATT	t	ATT	T
Numeracy Skills	0.34	0.47	0.40	0.54	0.55	0.80	0.37	0.45
Social-Emotional Skills	0.147	0.32	0.08	0.20	0.13	0.32	0.04	0.07
Whether participated in early childhood class								
Numeracy Skills	0.40	0.66	0.53	0.98	0.52	1.01	0.50	0.77
Social-Emotional Skills	−0.53*	−1.35	−0.45	−1.27	−0.47*	−1.37	−0.50	−1.13
Whether participated in parent–child class								
Numeracy Skills	−0.20	−0.17	−0.25	−0.24	−0.18	−0.18	−0.32	−0.29
Social-Emotional Skills	.02	0.04	−0.41	−0.76	−0.35	−0.66	−0.41	−0.55
Whether participated in sports-type off-campus training								
Numeracy Skills	0.72*	1.31	0.78*	1.51	0.80*	1.57	0.83*	1.50
Social-Emotional Skills	0.38	1.00	0.30	0.89	0.35	1.06	0.40	0.94
Whether participated in arts-type off-campus training								
Numeracy Skills	0.56	0.76	0.75	1.16	0.69	1.11	0.62	0.73
Social-Emotional Skills	0.16	0.37	0.37	0.93	0.34	0.89	0.41	0.87
Whether participated in culture-type off-campus training								
Numeracy Skills	0.06	0.11	−0.10	0.71	0.31	0.65	0.27	0.42
Social-Emotional Skills	−0.31	−0.75	−0.41	−1.12	−0.48*	−1.34	−0.53	−1.16
Whether participated in mind development-type off-campus training								
Numeracy Skills	0.59	0.94	0.76*	1.44	0.83**	1.65	0.80	1.06
Social-Emotional Skills	0.67*	1.44	0.27	0.67	0.16	0.40	0.11	0.20

*$p < 0.1$;**$p < 0.05$;***$p < 0.01$.

VI. Discussion of conclusions

(i). Participation in sports-type off-campus training contributes to improving preschoolers' numeracy skills

This study found that participation in sports-based off-campus training promoted the development of preschoolers' numeracy skills. It has also been exhibited that sports and exercise have improved executive function (Bai et al., 2022; Lu & Deng, 2021), which correlate with numeracy skills (Vanhala et al., 2023; Wolf & McCoy, 2019).

First, physical activity significantly predicted executive function, the process by which individuals self-regulate complex cognitive activities and orient their activities toward defined goals. Several national and international studies have exhibited that children's executive functioning can be improved by short bouts of physical activity that is of moderate intensity (Chen et al., 2011; Perone et al., 2019; Y. Wang, n.d.; Yang, 2020). In terms of brain mechanisms, physical activity promotes nutrient supply, energy metabolism, neuron survival, and synaptogenesis in brain cells (Perone et al., 2019). Further, physical activity enhances the volume of brain structures such as the hippocampus and cerebellum, and influences the level of activation of brain regions and functional connectivity between brain regions, thereby affecting children's executive functions (Perone et al., 2019). In terms of cognitive functioning, physical activity enhances children's cognitive functioning, metacognition, and memory, among other related abilities, so that cognitive improvement, in turn, positively correlate with numeracy skills (Huang et al., 2019; Jiang, 2021). The participation of preschoolers in different types of sports-based off-campus training, requires physical activity of moderate-intensity, varying intensity, and extended durations. They can positively influence brain mechanisms, further affecting executive function and cognitive abilities.

Second, executive functioning correlates with numeracy skills. Early childhood mathematical learning is significantly positively correlated with executive function, which is an important cognitive processing mechanism for children's mathematical learning (Kang & Zeng, 2018). Executive functioning correlates with preschoolers' numeracy skills in two distinct ways. First, executive functioning is a

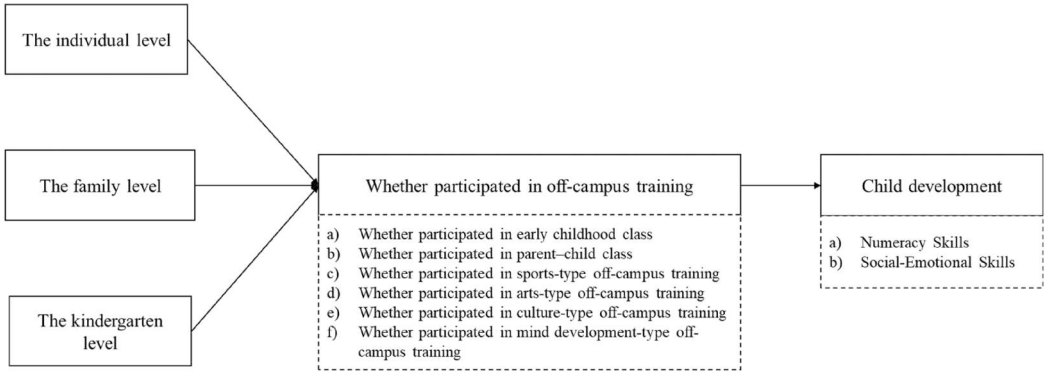

Figure 4. Model diagram for this study.

prerequisite and foundation for preschoolers' numeracy and reasoning skills and is a cognitive process necessary for supporting preschoolers' mathematical learning (Geary et al., 2012). Second, executive functioning improves children's self-regulation and influences interpersonal interactions, which in turn correlates with children's numeracy skills (Kang & Zeng, 2018).

(ii). Participation in off-campus training does not contribute to the improvement of preschoolers' numeracy and social-emotional skills

The second important finding was that participation in various types of off-campus training had no significant effect on the development of numeracy and social-emotional skills among preschoolers. Although off-campus training assisted preschoolers in getting ahead of the competition, it cannot effectively be related to their numeracy and social-emotional skills. In fact, the same findings have been made domestically and internationally (Shi et al., 2022a; Xue et al., 2023). Participation in early education classes has no continuous improvement effect on children's learning and development after entering kindergarten (Shi et al., 2022a). The effect of preschool out-of-kindergarten tutoring on improving children's approaches to learning was very limited. In particular, participation in subject-based tutoring to prepare for elementary school failed to improve children's approaches to learning (Xue et al., 2023). It was further verified that off-campus training participation did not have a significant impact on preschool development. This outcome was influenced by several factors, including preschoolers' individual aspects, off-campus training providers, and parental perceptions.

First, we will analyze the aspects related to preschoolers' learning and development patterns. Off-campus training exceeds the cognitive development levels of preschool children. Piaget proposed the cognitive-developmental theory: preschool children are in the perceptual-motor and pre-operational stages, mainly relying on sensory perception, movement, and concrete image thinking to recognize the world (Piaget, 1997). Off-campus training exceeds the cognitive development level of preschoolers and frequently employs forms of teaching and learning which are inconsistent with the way preschoolers understand the world.

The Guidelines for the Learning and Development of Children Aged Three to Six and the Guidelines for Kindergarten Education propose that preschool children may utilize playing as their basic activity and learn through their direct perception of things, hands-on experience, and practical manipulation (Du, 2011; Zou, 2013). Off-campus training generally provides a training programme with classes as the main learning activity. To see the training findings as soon as possible, off-campus training organizations teach with hard lectures and repetitive training, deviating from the purpose of employing playing as a basic activity (Yang et al., 2023; Yang & Huang, 2020; Zhou & Qi, 2022).

Second, the activities and quality standards of off-campus training institutions are not standardized (Dong & Zhao, 2024; Zhang & Zhan, 2023). Given the promulgation of the 'double reduction' policy, the issue of non-academic training for preschool children aged three to six has come to the fore. It focuses on incomplete training qualifications, unstandardized training practices, and disparate quality of training. The disorderly development of off-campus training institutions, overscheduled teaching, confusing fees, false propaganda, hidden safety hazards, and other chaotic situations directly affect the effectiveness of off-campus training concerning the development of preschool children (Liang et al., 2022). In terms of false propaganda, this may include fictitious teachers' qualifications and teaching experience, exaggerated training effects and strength of training institutions, and fabricated user reviews (Guo & Li, 2023; Li, 2021).

Third, regarding parental perceptions, some parents focus on the practice and mechanical training aspects of learning, highlighting the skills and methods of training, and therefore ignoring the development of artistic qualities, and the lack of cultivation of sentiment. Contrastingly, numerous children are shuttled between various kinds of off-campus training programmes at a young age. Parents overburden their children with excessive 'tuition,' causing them to lose interest in learning music, art, and other extracurricular activities (Sina Weibo Data Center, 2017; Wei & Xue, 2021).

VII. Policy recommendations

Based on the above findings and discussion, the main policy recommendations of this study are as follows:

First, the government may coordinate multi-departmental efforts to strengthen the supervision of off-campus training and regulate the conduct of off-campus training for preschool children. The government may coordinate with regards to education, science and technology, culture and tourism, sports, and other multi-departmental efforts to increase the regulation of non-academic off-campus training, clarify the division of labour among various departments, innovate regulatory models according to local conditions, and standardize off-campus training for preschool-age children.

Second, kindergartens should conduct physical activities with a mindfulness towards best practice approaches that take into account the learning, development, and well-being of preschool children. Kindergartens may focus on the influence of physical activities on the cognitive and non-cognitive abilities of preschool children, respect the age characteristics and developmental patterns of preschool children, guarantee two hours of outdoor activity time per day, guarantee the amount of exercise, as well as perform alternating static and dynamic activities.

Third, parents may consider establishing the concept of scientific parenting and take a rational perspective on the role, relevance, and benefits of off-campus training (Zhang, Sheng, et al., 2024a). Parents may consider whether to participate in off-campus training or which kind of off-campus training to select according to their children's needs, strengths, hobbies, physical and psychosocial capabilities, and other comprehensive factors. It is imperative that they do not blindly follow trends; instead, an informed approach is recommended. To achieve this, parents are encouraged to keep an eye on their child's health and wellbeing, which may include avoiding forcing their child to participate in off-campus training if they are unwell, or reducing the amount as well as the duration of off-campus training in a way that reflects the child's age and stage.

VIII. Limitations

This study has two key limitations. First, the study did not have a pre-test to determine whether the differences between the experimental and control groups were due to off-campus training. However, the PSM method was used in this study to eliminate the differences between the experimental and control groups, which in turn compensated for the absence of a pre-test. Second, the study only considered the effect of participation in off-campus training on the mathematical and

social-emotional skills of preschool children. It did not consider the effect of the duration of participation in off-campus training. This limitation is due to the fact that the independent variables of the PSM method must be Dummy Variables, which in turn leads to this limitation. Considering the effect of training duration on child development provides new directions for future research to develop.

Finally, off-campus training has very limited developmental benefits for preschoolers. We may look at the role of off-campus training on children's development in a rational manner, and regard off-campus training as a useful supplement to kindergarten education rather than a track that is ahead of its time. The most important finding of this study is that sports-based off-campus training has a causal effect on preschoolers' mathematical skills. Therefore, we should focus on opportunities to engage children in increased physical activity both in and out of school.

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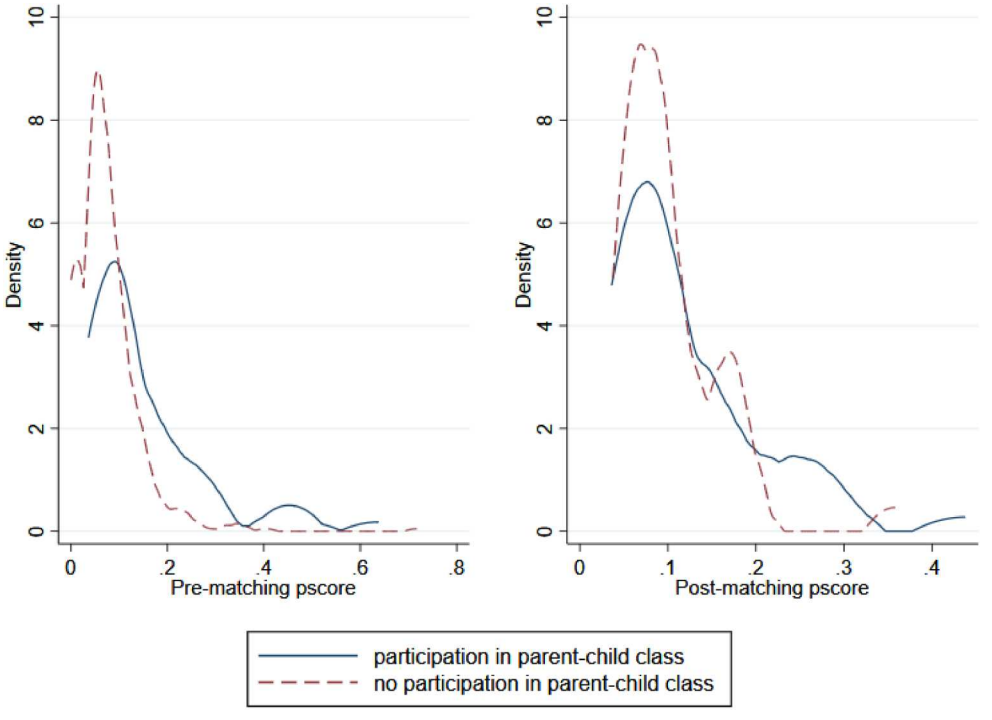
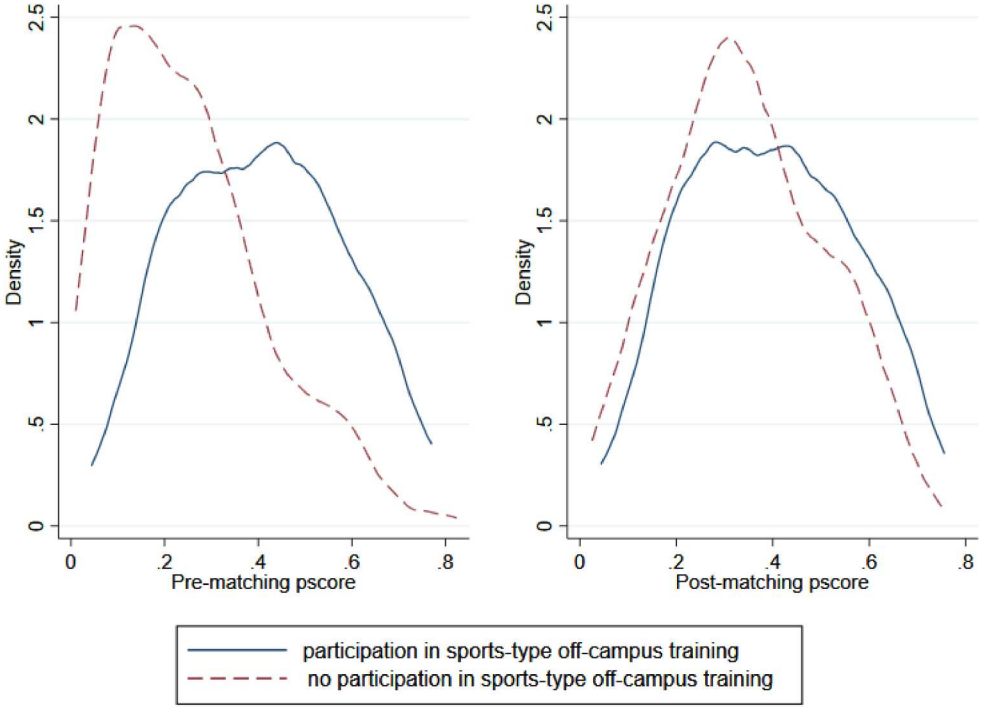
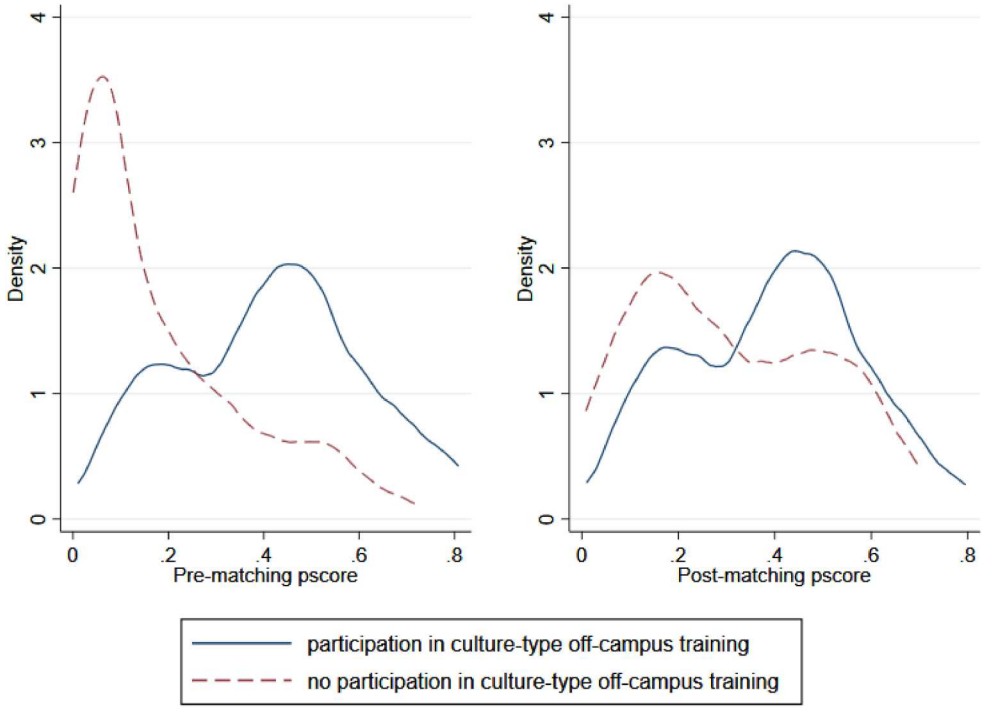
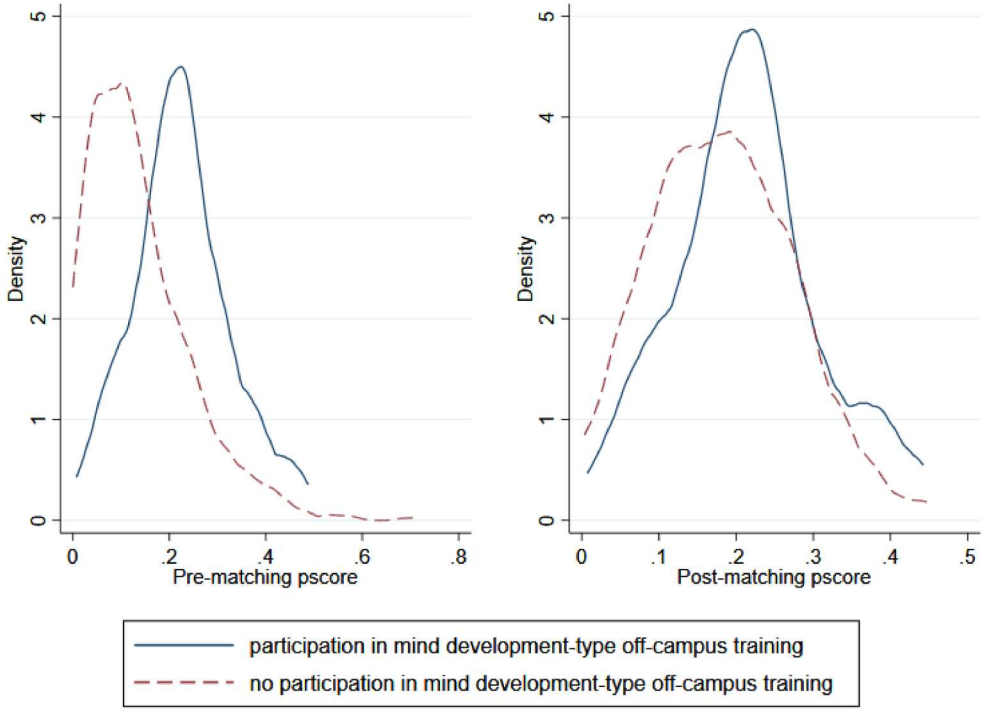
Annex 1

Figure A1-A6. Changes in the distribution of propensity scores before and after matching for each type of off-campus training.






Density
0
1
2
3
4
0
.2
.4
.6
.8
Pre-matching pscore
Post-matching pscore
participation in culture-type off-campus training
no participation in culture-type off-campus training


Density
0
1
2
3
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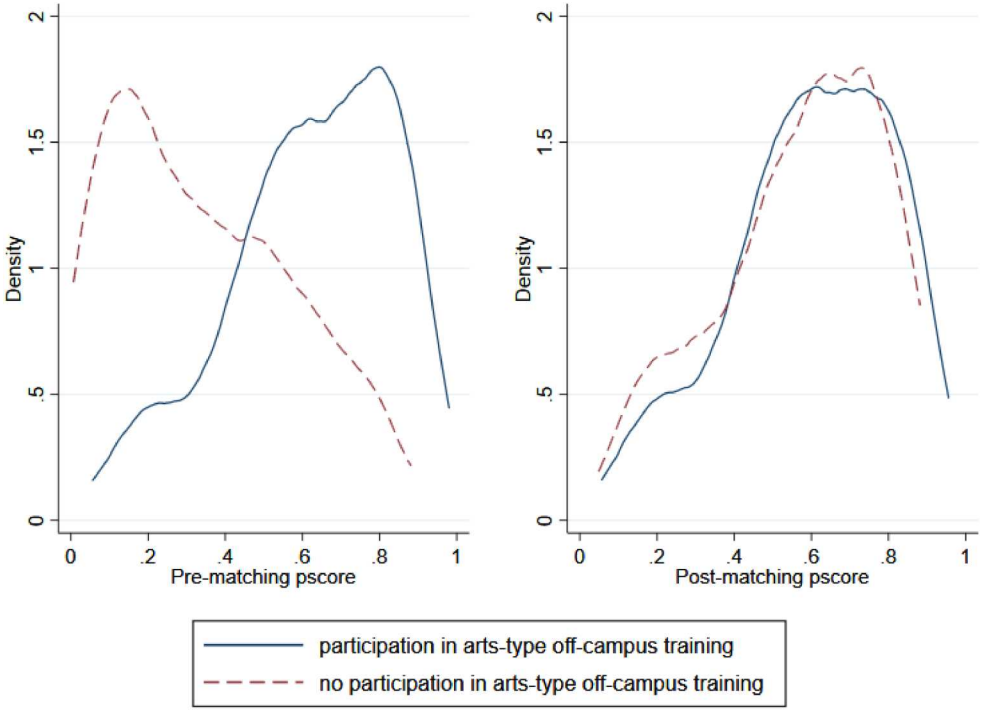
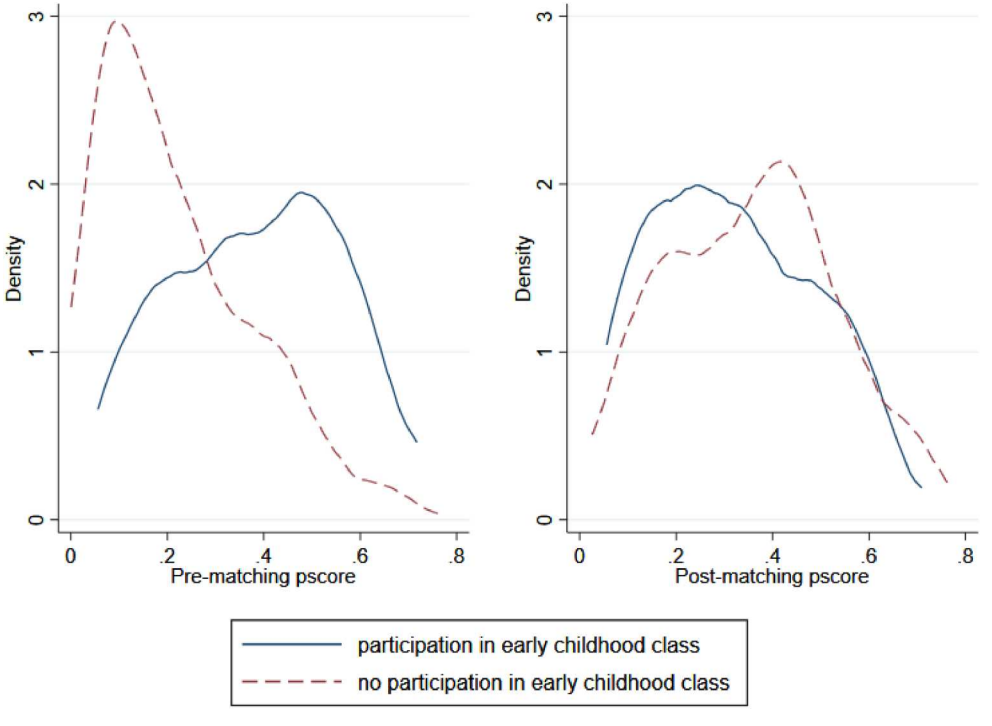
5
0
.1
.2
.3
.4
.5
.6
.8
Pre-matching pscore
Post-matching pscore
participation in mind development-type off-campus training
no participation in mind development-type off-campus training


Density
0
.5
1
1.5
2
0
.2
.4
.6
.8
1
Pre-matching pscore
Post-matching pscore
participation in arts-type off-campus training
no participation in arts-type off-campus training


Density
0
1
2
3
0
.2
.4
.6
.8
Pre-matching pscore
Post-matching pscore
participation in early childhood class
no participation in early childhood class