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Influence of Kindergarten Space Design on Development Quotient of Young Children

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ABSTRACT

The design of kindergarten spaces significantly impacts young children's physical and mental development. This research considers the influence of three dimensions of kindergarten space design, specific area, quality and use, on the development quotient (DQ) of young children. It considers this through regression and correlation analysis applied to survey data related to the spatial design of the three kindergartens in the aforementioned three dimensions, along with the DQ test scores of 270 young children. The results reveal a significant positive correlation between the three dimensions (area, quality and use) of kindergarten space design and young children's DQ. With regard to the dependent variable's influence on the five areas of young children's DQ, dependent variables had the largest influence on social behaviour, and then on language, gross motor and adaptability; however, they had no significant influence on fine motor. And finally, while the influence of these three dimensions on the DQ of male children was found to slightly exceed their impact on female children's DQ, this influence was not impacted by monthly age changes. In order to ensure the spatial environment positively affects young children's development, the results attribute particular significance to the index of the kindergarten indoor and outdoor per-student area; the extent to which space design is interesting; and the potential for diversification and the duration of use to evolve.

1. Introduction

Research has highlighted that students spend almost one-third (30 percent) of their time at school, which further underlines the potential for the quality of schools' indoor and outdoor environments to affect their future development [1]. They spend more time in school than in any indoor environment, apart from the home. However, the school environment can also negatively impact student learning and achievement in school, with both immediate and lifelong consequences for students and society [2] – lighting, access to nature, window characteristics, art/environmental aesthetics, and ergonomics/spatial arrangement are all important considerations in this regard, and so is the visual environment [3].

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During their development, children usually experience several sensitive periods when their abilities vary, which are known as critical periods of development. The child psychologist and educationalist Montessori observes:

Sensitive periods are the nature-endowed life help to children. Children will lose the best time to learn if their inner needs are not met and cannot be developed in sensitive periods. They have to spend more time and effort when learning it again in the future and even worse, the results will not be evident [4].

The development speed of children's intelligence is consistent with the development of their brains. The brain develops at the highest speed before three-years-of-age and its development then slows. In addressing this, the American psychologist B.S. Broom suggests that the period before a child turns seven-years-old is the crucial stage of their intellectual development [5]. A person reaches full intellectual maturity by 17-years-of-age, but has already reached 80 percent of this potential by the time they turn seven-years-of-age. The most important site for children to learn before 7 years old is kindergartens. As educational concepts keep updating, parents and teachers have gradually transformed from leaders of preschool education to guides. Furthermore, kindergartens as the most important learning space for children become the third guide after parents and teachers in the growth process of children. In this context, increasing attention has been paid to kindergarten space design. In addition, the space environment creates the external condition for the spiritual growth of children. Mr. Chen H Q said that, "Children obtain a particular impression under the stimuli of a certain environment", indicating that the space environment is playing a potential educational function all the time [6]. Studies have confirmed that green buildings significantly impact the IQ of young children aged six-years-of-age and below [7], and so it is essential to take the building of learning environments for young children into account.

From a design perspective, several studies have proven that the design and design elements of educational spaces have significant impact on the learning experience, which is most critical in the early years of education [8]. At present, the curriculum design of kindergartens is formulated for the better development of children's major abilities such as gross motor, fine motor, cognitive, emotional and social development, collectively referred to as children's "development quotient (DQ)". It is one of the core indices used to measure the mental development level of infants and young children. Specifically, the evaluation of DQ, which mainly covers such five areas as gross motor, fine motor, language, adaptability and social behaviour, is carried out to measure and survey the developmental behaviour of children and assess their developmental level. In addition, DQ is also one of the indices to objectively evaluate the intellectual development of infants and young children and it provides reliable evidence for their supernormal intelligence or developmental delay. Clinically, DQ is used as a tool to help comprehensively and systematically assess the developmental level of children [9].

When the situation in China is examined from a content system perspective, the existing research of kindergarten space design is still limited to traditional case analysis and a methodological focus on the "design" level, including buildings, landscape, planning and indoor and outdoor space. From an environmental education perspective, building creation practice is currently mainly focused on the campus design of universities and middle and primary schools [10]. However, the design concept of kindergartens has not been systematically formulated. However, some European countries and regions are putting forward applied research design concepts in this sector [11-15], and they are more developed than counterparts that have emerged in China.

The teaching of teachers is always taken to be the key preoccupation in kindergartens, and it is therefore expected that children will passively accept arrangements. In addition, the ‘campus construction’ is considered to be a concern for architects, so user needs and children's learning are not taken into account [16]. With regard to existing research in this sector, the structure of research

participants is simple. With the exceptions of coordination with design institutes and inter-school cooperation with architecture-related majors, there are no specialized research institutions or associations with noted achievements, and cross-regional and inter-disciplinary coordination is also absent [17]. In addition, the majority of the research into the development of young children is focused on medical care and the preschool education sectors, and no research has addressed young children's DQ in the wider context of children-related architecture, and this oversight has persisted despite its importance for contemporary kindergarten space design and potential to provide guidance. The kindergarten space design initially aims to promote children's comprehensive physical and mental development. This space is also the starting point of children's learning and growth, and its design should guarantee children's physical and mental development and boost their comprehensive development [19].

The kindergarten space design initially aims to serve their comprehensive physical and mental development. Such space is also the starting point of children's learning and growth, and its design bears the crucial duty to guarantee the physical and mental development of children and boost their comprehensive development [20]. The research of the correlation between kindergarten space design and young children's DQ not only provide a more explicit and intuitive reference for the future development of kindergarten architectural space design, but also promotes a more scientific and effective basic guarantee for the comprehensive development of kindergartens. This research therefore focuses on the influence of the space design of kindergartens (as the most important learning site in the critical growth period of children) and assesses how they influence the DQ of young children, with the aim of exploring the correlation between the two factors.

The *Code for Design of Nursery and Kindergarten Buildings* (JGJ39-2016), which was issued by the Ministry of Housing and Urban-Rural Development of the People's Republic of China and implemented in the period since November 1, 2016, establishes that the per-student area in kindergartens, per-student building area, area of outdoor activities and green area shall not (respectively) be less than 15m^2, 9 m^2, 6m^2, and 2m^2 [21]. But kindergartens in most areas of China do not emphasize the per-pupil area ratio of kindergartens [22], as the design and use of kindergarten space is confronted by more prominent problems. Second, young children have a strong need to communicate, and the design of kindergarten space structures should recognize this by helping to increase their willingness to participate in communication [23]. Young children's ability to understand and communicate develops through language use, and so the context of language utilization should be the focus of kindergarten spatial structure design. For example, public space (such as the kindergarten's lobby, corridor and staircase) is the regular facility, and it is easy to neglect the interactivity of the space by over-emphasizing the functionality of the public space [24]. This study attributes spatial interactivity and playfulness to the quality of the design of spaces for young children. Finally, the spatial structure of kindergartens is often "tied" to the design of teachers' instructional activities, and children may play at unpermitted times and places, producing spatial conflicts between teachers and children. Emphasizing flexibility in the use of spatial structures cultivates a democratic child-teacher relationship and a harmonious and inclusive atmosphere of growth in kindergartens [24], study has also shown that teachers' flexible use of space significantly impacts children's cognitive, motor, and emotional development[25]. One research study observes that young Chinese children have a low overall level of physical activity, and proposes that their length of free outdoor activities needs to increase [26]. This confirms that activity duration is one of the essential variables. This study attributes the flexibility of space use and duration of use to the dimension of space use.

This research explores how three dimensions of kindergarten space design, (area, quality and use) affect young children's DQ. Here, the area of space design mainly covered the kindergarten per-student building area, per-student outdoor floor area, and the ratio of kindergarten indoor public

space to building area (indoor public space is the space for children to carry out various activities, with the exception of the exclusive closed classroom, which includes the multi-functional, scientific discovery, reading and music and sports rooms, the foyer, and traffic space). A reverse scoring method was also performed on the area of space design and applied as a dependent variable. The quality of space design was represented by the extent to which space design was (measured by referring to the following aspects:

i. whether the space function partition design provides children with space for independent exploration
ii. whether the design of space modelling contains Interactivity and interesting points; whether the matching of space colours, texture performance of materials, and the use of lighting is interesting, at both functional and visual levels).

The use of space was manifested in both the flexibility of public space use (which was defined as the flexibility of space use level in aspects that included combination forms, enclosure changes , functional conversions and time alternation) and the average duration of use (as Figure 1).

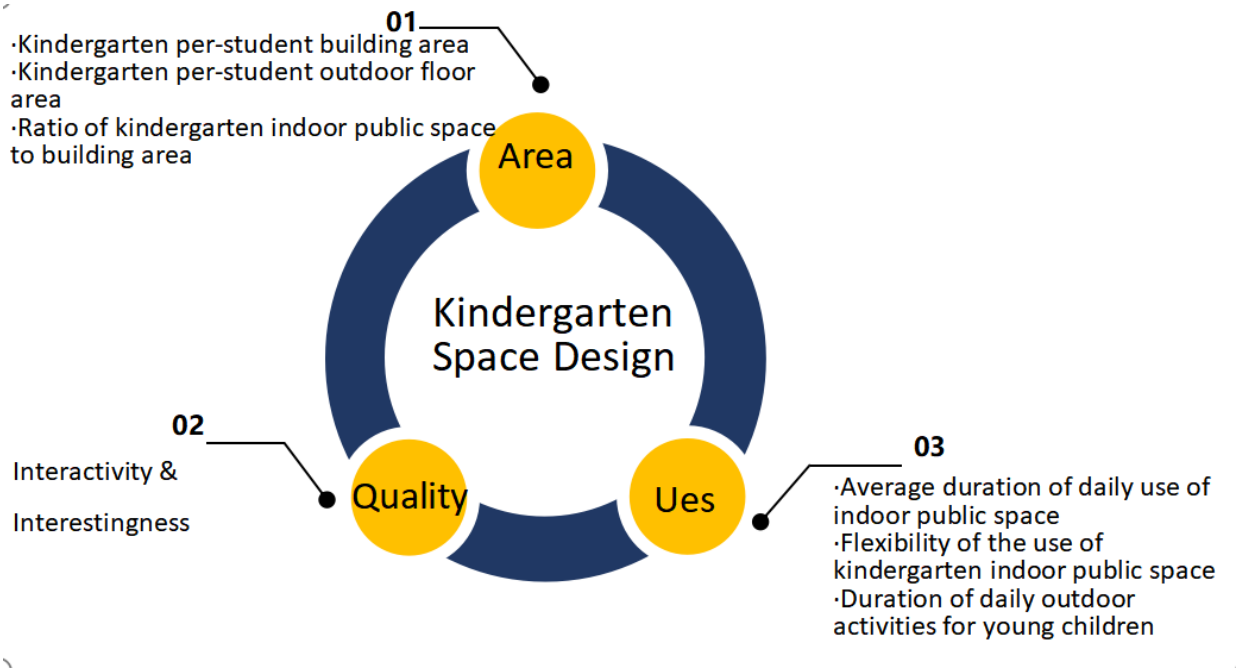

Fig. 1. Three dimensions of kindergarten space design

In referring to the preceding variables, this study addresses the following questions:

i. Is there an influential relationship between the area of kindergarten space and young children's DQ?
ii. Is there an influential relationship between the quality of kindergarten space design and young children's DQ?
iii. Is there a relationship between the use of kindergarten space design and young children's DQ?
iv. Is there any difference in the relationship between the effects of kindergarten space design on the children's DQ of different genders and months of age?

None of these questions have been systematically addressed by previous studies. This study addresses the influence exerted by the three dimensions (area, quality, and use) and assesses their impact on young children's developmental quotient in the spatial design of kindergartens. It does so in the expectation this will positively contribute to the future development of young children's kindergarten environment, and help the creation of spatial environments in kindergartens to receive wider attention.

2. Methodology

2.1 Data

This research collected data from a survey of kindergartens in Shandong Province that was conducted in March-April 2023.Most kindergartens classify children into junior, middle and primary classes in accordance with their age, and so an equal proportion stratified sampling method is used to randomly select samples that meet the grouping requirements. Most studies of early childhood development draw on samples that range between 200-300 children [27-29], and so three samples of 270 children were taken from three kindergartens (each kindergarten had 800-1000 students) and surveyed and measured. The three kindergartens selected belonged to the city of Jinan, Licheng District, and had significant variability in the area, quality, and use of the space designed. In each kindergarten, 30 children were selected from the junior, middle and primary classes, for 90 children. And the space design of three kindergartens and 270 children (3-6 years old) were included as analysis samples and assessed with reference to a number of variables that influence young children's DQ in preschool education, specifically: parents' educational background (both college degree or above); family income (100,000-300,000 yuan); kindergarten teachers' educational background; and teaching years (college degree or above, 3-5 teaching years). Each of these variables were controlled. After the consent of the kindergarten and guardians were first obtained, the Developmental Scale for Children aged 0-6 years-of-age and accompanying instruments were used to measure the children in small groups separated on the basis of monthly age.

2.2 Variables

The descriptive statistics of all variables are listed in Table 1. The present survey referred to the Developmental Scale for Children Aged 0-6 Years, which was issued by the National Health and Family Planning Commission of the People's Republic of China (now called the National Health Commission of the People's Republic of China) in December 2017 and which began to be implemented on April 1, 2018. It is a diagnostic scale that is used to assess the developmental behaviour level of children aged 0-6 years-of-age[1]. This scale covers five functional areas (gross motor, fine motor, language, adaptability and social behaviour) and provides 8-10 test items for each month's age group (261 test items in total). The measured data are classified into two types of intellectual age and DQ. The DQ score of each functional area is calculated by a special software system, and the intellectual age and total DQ score of infants and young children are obtained on the basis of the scores of these five functional areas by referring to the following formulae: intellectual age = the sum of the scores of each area/5 and DQ = (mental /actual month age) ×100. This research only measures the DQ of young

[1] Previous research confirms that the Developmental Scale can be used as the basic scale to formulate normal tables in China because it has high structural validity, strongly discriminated test items, a reasonably structured five-dimensional scale, and is consistent with the parameters of the diagnostic developmental assessment scale.

children by applying the reference range of >130 (excellent), 110-129 (good), 80-109 (moderate), 70-79 (critically low), and <70 (intellectual disability).

Table 1
Descriptive statistics

	Percentage
Gender	
Male	51.1
Female	48.9
Class	
Junior class	33.3
Middle Class	33.3
Senior Class	33.3
Month age	
36-42 months old	0.4
42-48 months old (except for 42 months old)	3
48-54 months old (except for 48 months old)	19.6
54-60 months old (except for 54 months old)	15.6
60-66 months old (except for 60 months old)	17.4
66-72 months old (except for 66 months old)	18.5
72-78 months old (except for 72 months)	17.4
78-84 months old (except for 78 months)	8.1
Kindergarten per-student building area	
≤5 m2	33.3
10-15 m2	33.3
16-20 m2	33.3
Kindergarten per-student outdoor floor area	
0-1 m2	33.3
1-2 m2	66.7
Ratio of kindergarten indoor public space to building area	
20-30%	33.3
30-40%	33.3
40-50%	33.3
Average duration of daily use of indoor public space	
≤30 min	33.3
30-60 min	33.3
1.5-2 h	33.3
Interactivity and Interestingness of kindergarten space design	
Less interactive and relatively boring	33.3
Relatively interactive and interesting	33.3
Interactive and Interesting	33.3
Flexibility of the use of kindergarten indoor public space	
Insufficiently flexible	33.3
Flexible	66.7
Duration of daily outdoor activities for young children	
≤30 min	33.3
1-1.5 h	33.3
1.5-2 h	33.3

Kindergarten space design was taken as the dependent variable. The detailed space design data of the three kindergartens surveyed were collected, and mainly included kindergarten per-student building area, per-student outdoor floor area, ratio of kindergarten indoor public space to building area, interestingness of space design, flexibility of use of space design, average duration of daily use of indoor public space, and duration of daily outdoor activities for young children (Table 1). Young

children's DQ was the core independent variable, which was measured on a one-to-one basis with 270 children. Specialized scale measurement software and accompanying instruments were used to produce individual test scores that included the DQ test scores and each of the five components (gross motor, fine motor, language, adaptability and social behaviour).

Previous studies have observed that children's early-stage intellectual development is influenced by the family's nurturing environment [30]. In this research, the family background was measured by referring to parents' educational background and family income. Teachers' teaching experience, another key variable that influences children's DQ, was measured by referring to kindergarten teachers' educational background and teaching years. In order to guarantee the reliability of the research results, the stratified sampling of survey samples was conducted by referring to large data statistics of the survey area. In most cases, the parents of young children have a college degree or above and a family income of 100,000-300,000 per year; and kindergarten teachers have a college degree or above and 3-5 years of teaching experience. In the three selected kindergartens, children whose four dependent variables were at the same level were chosen as research samples. Their features, including age, gender and month were also included as independent variables that would be used in later analysis.

2.3 Methods

In undertaking data analysis, correlation and regression analysis, which are commonly used to analyse variable correlations, were used to explore the correlation between the dependent variables of kindergarten space design in the three dimensions and young children's DQ. First, regression analysis, was used to study kindergarten space design in the two dimensions of area and use and to assess how it affected the young children's DQ scores with regard to their gross motor, fine motor, adaptability, language and social behaviour, that is used to analyse quantitative correlations between independent variables. Correlation analysis, was then used to analyse the correlation between kindergarten space design and the DQ of young children of different ages, genders and months, to measure the level of correlation between the two variables.

2.4 Basic Introduction to Kindergarten Space Design and Use Situation

The statistical data show that Shandong Province, as the most populous province in China, ranked first in the country in terms of increases in the birthrate, (39.76 percent), birthrate (17.54 percent) and newborn population (1.74 million) since 2017.However, preschool education reform has lagged due to a relatively conservative mindset. To ensure that the reformed and expanded kindergarten meets the current needs of preschool education, this study discusses in depth the issues related to the spatial planning of kindergartens in Shandong, and provides assistance for the reform of preschool education space in Shandong in the context of deepening the comprehensive reform of preschool education.

According to in-depth research, kindergarten space design in Shandong Province mainly has the following problems:

2.4.1 Neglect of kindergartens' construction planning

In China, kindergarten construction space design shows great hysteresis quality and irrationality, and this is because most kindergartens focus on indoor decoration and give little consideration to the space design of initial construction planning [31]. Less attention has been given to the openness

of the space, and the planning method with closed classes at its centre that operates in a traditional way has been employed, which has resulted in a lack of public space area and children from different classes who are of different ages being unable to access an interactive space [32]. As a result, the implementation of preschool education has been impeded and impacted to a certain extent.

2.4.2 Kindergarten space planning and design being detached from the educational concept

With the continuous development and renovation of the preschool education concept, the interaction between young children in social activities, including game-playing, cooperation and communication, has been attributed great importance [33]. As a result, it has been seen as necessary to design indoor and outdoor space to ensure that it satisfies the implementation of the educational concept [34]. But the indoor and outdoor space design of most kindergartens shows a serious hysteresis quality problem, and this is because they do not acknowledge and adhere to the renovation and development of the concept of young childhood education.

2.4.3 Lack of open space planning and potential of diversity evolution in kindergartens

The open space of kindergartens plays a highly important part in preschool education as it enables young children to break the barriers of class and age and independently choose a variety of social interactions and provide a kind of safeguard at the spatial dimension level that enhances their adaption, communication and problem-solving, and contributes to the development of their gross motor. But previous studies have found there is insufficient space to plan public space, and this is attributable both to a shortage of land at most kindergartens and a lack of awareness of the need to take open space planning seriously. With regard to existing public space, there is a lack of acknowledgement of the potential of diversity evolution, space use is insufficiently flexible and insufficient energy has been invested into the diversified utilization and renewal of indoor and outdoor open space.

2.4.4 Shortage of the design and use of kindergarten outdoor space

This study highlights that it is difficult for most kindergartens in Shandong Province to meet the standard of per-student outdoor floor area that is anticipated by relevant documents, and this is due to shortages of planning land. Scheduled outdoor activities generally last for less than one hour, which is far below the two hours suggested by preschool education guidance documents.

3. Results

3.1 Kindergarten Space Design and DQ of Young Children

3.1.1 Factors that influence relations between the area of kindergarten space design and young children's DQ

The results of study show the correlation coefficients of kindergarten per-student building area, kindergarten per-student outdoor floor area and ratio of kindergarten indoor public space to building area under the area of kindergarten space design were, when considered in relation to the DQ, found to be positive, at 0.53, 0.43, and 0.56 (respectively), with p values less than the significance level of 0.01. These results suggest a positive correlation.

Table 2
Correlation analysis

	DQ	Kindergarten per-student building area	Kindergarten per-student outdoor floor area	Ratio of kindergarten indoor public space to building area
DQ	1			
Kindergarten per-student building area	0.53**	1		
Kindergarten per-student outdoor floor area	0.43**	0.95**	1	
Ratio of kindergarten indoor public space to building area	0.56**	0.98**	0.87**	1

* Correlation is significant at the 0.01 level (2-tailed)

The kindergarten per-student building area, per-student outdoor floor area and ratio of indoor public space to building area under the area of kindergarten space design were subjected to dimensionality reduction by applying the Factor Analysis Method, and this made it possible to obtain the resulting area of kindergarten space design synthesizing factors (Table 3). The influential relationship between the area of kindergarten space design and the DQ of young children was then explored by using the area as an independent variable. The regression coefficient of this independent variable was 5.77 (a positive value) and the corresponding p value was 0.01, below the significance level 0.05 (Table 3). It can therefore be observed that the area of kindergarten space design had a significant positive impact on the DQ: one unit increase in the area of kindergarten space design once would produce 5.77 units of positive impact on the DQ.

Table 3
Coefficient of regression analysis

	Dependent variable: DQ	
	B(SE)	t
(Constant)	94.973(1.46)	64.87**
Area of kindergarten space design	5.77(0.57)	10.18**
R2	0.28	
ΔR2	0.28	
F	103.54**	

** indicates a significant effect at the 0.01 level
* indicates a significant effect at the 0.05 level

The three kindergartens also showed clear differences in the area of space design. Combining Table 2 and 3 showed the area of different kindergarten space design significantly impacted the DQ.

3.1.2 Influential relationship between the quality of kindergarten space design and young children's DQ

The results shows that the correlation coefficient (of the interestingness of kindergarten space design under the quality of kindergarten space design) with the DQ was 0.56, a positive value. Meanwhile, the p value was less than the significance level for 0.01, which signified a positive correlation (Table 4).

Table 4
Correlation analysis

	DQ	Interactivity and interestingness of kindergarten space design
DQ	1	
Interactivity and interestingness of kindergarten space design	0.56**	1

* Correlation is significant at the 0.01 level (2-tailed)

The results display the influential relationship between the quality of kindergarten space design and young children's DQ, which was explored by using the interestingness of kindergarten space design as an independent variable. Table 5 shows the regression coefficient of the interestingness of kindergarten space design was 6.21, a positive number, and the corresponding p value was 0.01, below the significance level for 0.05. On this basis, it is concluding the quality of kindergarten space design had a significant positive impact on the DQ – one unit increase in the quality of kindergarten space design once would produce 6.21 units of positive impact on the DQ.

Table 5
Coefficient of regression analysis

	Dependent variable: DQ	
	B	t
(Constant)	96.66(1.22)	79.29**
Interactivity and interestingness of kindergarten space design	6.21(0.56)	11.00**
R2	0.31	
ΔR2	0.31	
F	121.05**	

** indicates a significant effect at the 0.01 level
* indicates a significant effect at the 0.05 level

Combining Table 4 and 5 shows the quality of different kindergarten space design significantly impacts DQ, and this is due to differences in the three kindergartens' space design quality.

3.1.3 Influential relationship between the use of kindergarten space design and young children's DQ

The results show the correlation coefficients of the average duration of daily use of kindergarten indoor public space, flexibility of the use of kindergarten indoor public space, and duration of daily outdoor activities for young children were, under the use of kindergarten space design, positively correlated with the DQ at (respectively) 0.57, 0.43 and 0.53; meanwhile, p values were less than the significance level 0.01, which indicated a positive correlation.

Table 6
Correlation analysis

	DQ	Average duration of daily use of kindergarten indoor public space	Flexibility of the use of kindergarten indoor public space	Duration of daily outdoor activities for young children
DQ	1			
Average duration of daily use of kindergarten indoor public space	0.57**	1		
Flexibility of the use of kindergarten indoor public space	0.43**	0.76**	1	
Duration of daily outdoor activities for young children	0.53**	0.93**	0.95**	1

The results show the use of kindergarten space design synthesizing factors obtained for dimensionality reduction of the average duration of daily use of kindergarten indoor public space; flexibility of the use of kindergarten indoor public space; and duration of daily outdoor activities for young children under the use of kindergarten space design. Each was obtained through factor analysis. The influential relationship between the use of kindergarten space design and young children's DQ was then explored on this basis as an independent variable. Table 7 shows the regression coefficient of the independent variable (the use of kindergarten space design) was positive (5.20), and the corresponding p value was 0.00, less than the significant level 0.01, which demonstrated the use of kindergarten space design had a significant positive impact on the DQ – one unit rise in the use of kindergarten space design would have 5.20 units of positive impact on the DQ.

Table 7
Coefficient of regression analysis

	Dependent variable: DQ	
	B	T
(Constant)	97.51(1.17)	82.89**
Use of kindergarten space design	5.20(0.49)	10.71**
R2	0.30	
ΔR2	0.30	
F	114.59**	

** indicates a significant effect at the 0.01 level
* indicates a significant effect at the 0.05 level

Combining Table 6 and Table 7 shows that the use of different kindergarten space designs has a significant impact on the DQ, and this is due to differences in the space design use among the three kindergartens.

3.2 Ranks of the Influence of Two Dimensions (the Area and Use of Kindergarten Space Design) on Young Children's Gross Motor, Fine Motor, Adaptability, Language and Social Behaviour. The Rankings Descend from the Largest to the Smallest.

The regression analysis method was used to explore the influence of two dimensions (the area and use of kindergarten space design) on young children's gross motor, fine motor, adaptability, language and social behaviour. Regression models were established with the area and use of space design as independent variables; the gross motor test score, the fine motor test score, the

adaptability test score, the language test score and the social behaviour test score were respectively established as dependent variables (Table 8). The area and use of space design as the independent variables were found to have a significant impact on the social behaviour test score. The regression coefficient of the area of space design was -36.5; the use of space design was 37.08; and the corresponding p values were both less than the significance level 0.01, which suggested selecting the area and use of space design as independent variables significantly impacted the social behaviour test score. The regression coefficient of the use of space design was negative, which confirmed a significantly negative impact; and the use of space design was positive, which implied a significant positive impact. Similarly, selecting the area and use of space design as independent variables significantly impacted the language test score, the fine motor test score and the adaptability test score. However, it did not significantly impact the fine motor test score. The area of space design had a significant negative impact, and the use of space design had a significantly positive impact.

The area and use of kindergarten space design had the greatest impact on the social behaviour test score, followed by the language test score, the gross motor test score next and the adaptability test score. However, it had no obvious impact on the fine motor test score.

Table 8
Summary of regression model

Variable	Dependent variable									
	Gross motor test score		Fine motor test score		Adaptability test score		Language test score		Social behaviour test score	
	B	T	B	T	B	T	B	T	B	T
(Constant)	115 (4.95)	23.25**	91.21 (3.84)	23.74**	103.06 (3.81)	27.08**	108.14 (3.37)	32.05**	115.48 (4.5)	25.68**
Area of space design	-13.77 (8.69)	-1.59	-5.74 (6.75)	-0.85	-10.29 (6.68)	-1.54	-18.01 (5.93)	-3.04**	-36.5 (7.90)	-4.62**
Use of space design	16.33 (7.56)	2.16*	11.18 (5.87)	1.91	13.83 (5.81)	2.38*	19.96 (5.15)	3.87**	37.08 (6.87)	5.40**
R2	0.11		0.27		0.19		0.21		0.22	
ΔR2	0.10		0.26		0.19		0.21		0.22	
F	16.07**		48.76**		32.17**		35.84**		38.49**	

** Correlation is significant at the 0.01 level (2-tailed) / * Correlation is significant at the 0.05 level(2-tailed)

3.3 Relationship Between Kindergarten Space Design and Young Children's (with Different Genders and Monthly Ages) DQ

3.3.1 Influential relationship between kindergarten space design and (young male and female) children's DQ

Table 9 and Table 10 show the three dimensions under kindergarten space design were slightly more correlated with the DQ of male than female children. A significant positive correlation was also found between kindergarten space design and the DQ of male and female children.

Table 9
Correlation analysis (male children)

	DQ	Interactivity and interestingness of kindergarten space design	Area of kindergarten space design	Use of kindergarten space design
DQ	1			
Interactivity and interestingness of kindergarten space design	0.61**	1		
Area of kindergarten space design	0.58**	0.98**	1	
Use of kindergarten space design	0.60**	0.99**	0.99**	1

** Correlation is significant at the 0.01 level (2-tailed) / * Correlation is significant at the 0.05 level (2-tailed)

Table 10
Correlation analysis (female children)

	DQ	Interactivity and interestingness of kindergarten space design	Area of kindergarten space design	Use of kindergarten space design
DQ	1			
Interactivity and interestingness of kindergarten space design	0.51**	1		
Area of kindergarten space design	0.48**	0.98**	1	
Use of kindergarten space design	0.50**	0.99**	0.99**	1

** Correlation is significant at the 0.01 level (2-tailed) / * Correlation is significant at the 0.05 level (2-tailed)

3.3.2 The influence of kindergarten space design on the DQ of children of different (monthly) ages

The relationship between kindergarten space design and the DQ of children of different (monthly) ages was explored by undertaking correlation analysis. Table 11 shows that the correlation coefficient of the area of kindergarten space design, use of kindergarten space design and interestingness of kindergarten space design (under kindergarten space design) with the DQ of children of different (monthly) ages was about 0.6, confirming a significant positive correlation. It can therefore be concluded that the effect of the influential relationship on children's DQ was less affected by changes in monthly ages.

Table 11
Correlation analysis (young children of different month ages)

DQ (correlation coefficient r) Space design	42~48 months (n=9)	48~54 months (n=53)	54~60 months (n=42)	60~66 months (n=47)	66~72 months (n=46)	66~72 months (n=46)	78~84 months (n=31)
Area of kindergarten space design	0.77*	0.68**	0.55**	0.55**	0.67**	0.78**	0.55**
Use of kindergarten space design	0.77*	0.66**	0.58**	0.62**	0.70**	0.74**	0.51**
Interactivity and interestingness of kindergarten space design	0.77*	0.65**	0.60**	0.66**	0.72**	0.71**	0.47**

** Correlation is significant at the 0.01 level (2-tailed) / * Correlation is significant at the 0.05 level (2-tailed)

4. Conclusion

The study's regression analysis confirms a significant positive correlation effect between the area, quality and use of kindergarten space design and young children's DQ. This indicates that in the future, particular emphasis should be placed on the planning and design of kindergarten per-student building area, the per-student outdoor floor area and the ratio of kindergarten indoor public space to building area and other relevant problems. Blindly expanded enrolment should not be pursued and reasonable indoor and outdoor per-student area should instead be a desired objective. In addition, the importance of the planning and design of open public space should be acknowledged, and designers and users should give full play to their subjective initiative with the aim of improving the potential of spatial diversification evolution and applying flexibility in a way that helps to create an interesting and changeable space. These actions will help to improve the general DQ index of young children.

This research also applied regression analysis to explore how two dimensions (area and use of kindergarten space design) influence five areas (gross motor, fine motor, adaptability, language and social behaviour) of young children's DQ. It then proceeded to rank these influences. The results revealed that the two dimensions had the largest influence on social behaviour, followed by language, gross motor and adaptability. However, when fine motor was considered as an independent variable, it was not evidently influenced by the two dimensions. And the area of space design (reverse scoring) negatively influenced social behaviour, language, gross motor and adaptability – however, it was observed a larger area was not better, and that it should be reasonable. The use of space design had a positive effect on the four independent variables. On this basis, it can be proposed that a reasonable per-student area, a larger open space and flexible use of space can contribute to the positive development of social behaviour, language and gross motor and can also help to enhance the adaptability of young children.

Finally, this research also included the gender and month age of young children as control variables that could be used to analyse the effect of kindergarten space design on young children's DQ. The results of the correlation analysis showed the three dimensions of kindergarten space design were slightly more correlated with DQ in male than female children; in addition, kindergarten space design was found to be obviously positively correlated with the DQ of both male and female children. Second, the correlation coefficient between kindergarten space design and the DQ of young children with different monthly ages was found to be around 0.7, which showed a significant positive correlation. On this basis, it was found that the effect of the three dimensions on young children's DQ was less affected by changes in monthly age.

The effect of kindergarten space design on young children's DQ was accordingly explored by referring to the three dimensions, and it was confirmed the three dependent variables affected independent variables. But data limitations mean that the study shows a number of deficiencies. First, reverse scoring was employed in the area of kindergarten space design, meaning the study results were negatively influenced. Second, only one item relates to the quality of kindergarten space design, resulting in relatively strong co-linearity between quality and other two variables in the examination of the three dimensions as independent variables. The quality dimension was filtered, meaning study results were contingent to some extent. Third, the number of variable samples were limited, meaning the structural reliability of the study's analysis of results was not ideal. It is therefore essential to carry out larger investigations of kindergarten space design in China and to improve research methods and tools with the aim of promoting kindergarten space design that will better serve preschool education.

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